

# Trade Disputes, Quality Choice, and Economic Integration

Richard Chisik\*

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**Abstract:** Recent work demonstrates the importance of developing high quality output in order to compete in export markets and other recent studies verify the prevalence of fixed and ongoing trade costs while participating in those markets. I consider the joint choice of quality and export promotion costs when trade relationships are subject to temporary disputes. When transparency is low and macroeconomic instability is high, disputes arrive more frequently and, therefore, firms may inefficiently choose lower levels of quality and export promotion. These, in turn, build shallower trading relationships with less trade volumes and higher tariffs, and generate greater trade reductions during the more common trade disputes. Several institutional features of the WTO dispute settlement mechanism that are generally lacking in preferential trade agreements such as improved transparency, dispute investigation, and the provision to recommend asymmetric continuation payoffs can ameliorate these inefficient quality choice outcomes. Hence, lower quality output and lower quality trading relationships may be more endemic to countries that depend on preferential trading areas as opposed to the WTO.

**JEL Classification:** F13, F15, C73, K33.

**Key Words:** Quality Choice, Irreversibilities, Economic Integration Dispute Settlement, Dynamic Games, WTO, Preferential Trade Agreements.

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\* Department of Economics, JOR-211, Ryerson University, Toronto, ON, M5B 2K3. I am grateful to seminar participants at Erasmus University, Katholieke Universiteit Leuven, University College Dublin, University of Nottingham, and the Mid-West International Economics Meetings at The Ohio State University. I would also like to thank the editor Bob Staiger and two anonymous referees for many useful suggestions. I, alone, am responsible for any remaining errors.

## 1. Introduction

The importance of producing high-quality output has begun to receive serious attention in the international trade literature. One group of studies demonstrates that high-quality production is critical in fostering economic growth and development.<sup>1</sup> Another group of recent studies suggests that developing high-quality production skills is necessary for firms that export.<sup>2</sup> On the other hand, participating in those export markets requires ongoing trade and export promotion costs.<sup>3</sup> In this paper we analyze how the joint decision over export quality and the commitment to trade costs are made when trade relationships are subject to temporary disputes. Our idea is that the quality of the trading arrangement can have important and previously unrealized effects on the quality of output.

Many types of trade disputes occur inside and outside of the multilateral trading system (WTO) as well as in preferential trade agreements (PTAs).<sup>4</sup> These disputes may be triggered by egregious actions (such as dumping), however, when trade policies are not perfectly transparent they may also be triggered by macroeconomic or preference fluctuations (and erroneous antidumping claims). Evidence that developing countries use antidumping actions in response to macroeconomic shocks is given by Bown (2007). The use of antidumping measures, however, are not at all limited to developing countries. The majority of dumping allegations have been made by OECD countries and as Prusa (1992, 1997, 2001), Blonigen and Bown (2003), Blonigen and Prusa (2003), and Prusa and Skeath (2004) have

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<sup>1</sup> See for example, Grossman and Helpman (1991), Hausman et al., (2007), and Rauch (2007). Early analyses are provided by Linder (1961) and Vernon (1966).

<sup>2</sup> Alvarez and Lopez (2005) provide evidence for Chile, Brooks (2006) for Colombia, and Hallak (2006) for a larger group of countries.

<sup>3</sup> Roberts and Tybout (1997) and Das et al. (2007) provide evidence of these costs for Colombia. Evidence for France is provided by Eaton, Kortum, and Kramarz (2006). These costs are related to the theories of export hysteresis developed by Baldwin and Krugman (1989), and Dixit (1989), and, more recently, by Alessandria et al. (2008).

<sup>4</sup> In this paper we consider trade disputes brought about by claims of unfair trade practices such as those described in Article VI of the GATT (antidumping and countervailing duties). Disputes in the present context generally do not refer to safeguards for emergency protection of a threatened industry (GATT Article XIX), exceptions for moral, health or environmental concerns (GATT Article XX), or renegotiation (GATT Article XXVIII). This distinction is relevant here because we model trade disputes as being generated by the misinterpretation of macroeconomic and preference fluctuations rather than a response to a stated change in importer policy. Antidumping claims are important for consideration because they have comprised the majority of safeguard and exceptions filed under the GATT/WTO and they are the single largest source of trade disputes. Although the number of dumping allegations reported to the WTO steadily declined from 366 in 2001 to 163 in 2007 their number increased again in the recession of 2008 and 2009 to 208 and 209 respectively.

demonstrated, these claims are not usually triggered by dumping, however, they are facilitated by imperfect observability of the available evidence.

To develop the relationship between quality choice and trade disputes we consider a dynamic game of tariff liberalization between two production economies with exogenous shocks that generate periodic trade wars. The cooperative level of trade barriers (as represented by an equivalent tariff) are enforced by the threat of retaliatory punitive tariffs. In addition to opportunistic behavior, however, the terms of trade is affected by macroeconomic and preference fluctuations. Even when countries do not wish to abrogate a trade agreement these external shocks can generate disputes. We consider trigger strategies as introduced by Green and Porter (1984) and adapt them to the international trade framework using the results of Abreu et al. (1990) and Fudenberg et al. (1994). Hence, exogenous shocks generate trade wars even when both countries abide by the agreement. These fluctuations are more likely to trigger disputes when non-tariff barriers are less transparent, or when countries choose not to see them clearly.

Quality choice is made by firms at the inception of the trade agreement. We assume that the incremental, and ongoing, trade, export promotion, and product development costs are related to the quality choice. In particular, higher quality products require that a higher percentage of these costs be paid in every period, even during a period of reduced export receipts, such as those that arrive during a trade dispute. Our idea is that irreversibilities arise from developing and maintaining network and sales infrastructure in the importing country, however, they may also arise from increasing output in an export sector or fitting exports to the importing country's standards.

Our first main result is that when transparency is low and macroeconomic instability is high, so that harmful trade disputes are more common, firms may inefficiently choose lower levels of quality and of export promotion in order to avoid the greater irreversibility that accompanies higher quality. We next show that the quality and irreversibility choices generated by stability and/ or transparency affect the quality of the trade relationship. In particular, lower-quality more easily-reversible output generates shallower trading relationships with less trade volumes and higher tariffs. Furthermore, it generates greater trade reductions during each of the more frequently occurring trade disputes. In this way trade

disputes affect not only quality choice but also the resulting level of economic integration.<sup>5</sup>

Having identified trade disputes as the source of the quality-choice economic-integration problem we next look at dispute settlement to provide a solution. The perception of unfair trade practices can be contested in several ways. First, the retaliation can proceed without notification to the WTO. For example, disputes originating in PTAs need not be notified to the WTO. Second, certain unilateral actions or the unilateral withdrawal of preferences granted under the generalized system of preferences can proceed without WTO notification.<sup>6</sup> Third, many unilateral actions (such as antidumping duties) are notified to the WTO but are not contested in the WTO. We refer to these first three groups that do not make use of the WTO's dispute settlement mechanism (DSM) as having weak dispute settlement (WDS). We contrast these three groups with the fourth group of disputes that proceed to the WTO's DSM and we refer to this fourth group as having strong dispute settlement (SDS).

Our idea is that several institutional features of the WTO's DSM that are generally lacking in PTAs or unilateral actions can ameliorate these inefficient quality choice outcomes. In the WTO a standing third-party (independent) tribunal reviews policies and claims, makes binding rulings, and authorizes remedies. Looking at Table 1, which describes the levels of legalization in some PTAs, we see that many PTAs have no provisions for any review, rulings, or remedies.<sup>7</sup> Others only have ad hoc tribunals and in many of these cases their recommendation is not binding. Only in a precious few PTAs is the review performed by a standing tribunal that makes a binding ruling, however, even in some of these most legally developed PTAs the tribunal cannot impose remedies. In contrast to PTAs, two powerful remedies of article 22 of the WTO's dispute settlement understanding is that it sanctions selective retaliation and limits the amount of allowable retaliation.<sup>8</sup> In a similar vein, many antidumping

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<sup>5</sup> The idea that the quality of trading relationships matters has also been examined by Ben-David (2000) who shows that it is not openness per se but rather trade intensity that leads to convergence across countries. Similarly, Hoekman and Kostecki (2001) point out that poor land-locked countries surrounded by other poor countries do not see any growth from international trade.

<sup>6</sup> For example, the US Trade Representative's special 301 process investigates countries that deny protection of intellectual property or do not allow adequate market access to goods that rely on intellectual property protection. In 2001, Ukraine was found to not adequately enforce copyrights on music CDs, and the US retaliated by the selective withdrawal of preferences and the levying of prohibitive tariffs on metals, footwear and other Ukrainian imports.

<sup>7</sup> For more on levels of legalization in PTAs see McCall Smith (2000).

<sup>8</sup> It should be noted that although the signatories to the GATT recognized the importance of effective dispute settlement in the formation of the WTO they do not extend the WTO's mediation functions to settle disputes arising

cases begin with an arbitrary initial retaliatory tariff, which is then often countered by a retaliatory antidumping claim.<sup>9</sup> The resulting grim free-for-all is markedly different from the selective and limited retaliation administered by the WTO's DSM.

Our third main point is then that the quality of dispute settlement matters. First, the increased enforcement capability of the WTO allows it the provision to recommend targeted retaliation and temporary asymmetric continuation payoffs. These are shown here to generate quality and integration outcomes that are superior to those engendered by the symmetric trade wars evidenced in many PTAs or in antidumping and other unilateral actions.<sup>10</sup> Second, the improved transparency in the WTO reduces the frequency of disputes, which reinforces the first effect. Hence, lower quality output and lower quality trading relationships may be more endemic to countries whose trade is more concentrated within an unstable PTA, or more subject to unilateral actions. Furthermore, limited integration may help explain why many PTAs are stillborn, and many others lead to no noticeable trade creation or diversion. Even Mercosur, which is the world's largest enabling clause justified PTA, has led mostly to trade diversion of lower quality products in which the region does not have a comparative advantage (Yeats, 1998). The limited economic integration in Mercosur was well expressed as "the main rule in place within Mercosur goes something like, 'When the going gets tough, it's every country for itself.'"<sup>11</sup> A similar quality outcome occurred in the Central American Common Market (Fox, 2004).<sup>12</sup>

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in PTAs. In fact, neither Article XXIV of the GATT 1947 which allowed for the formation of PTAs, nor the 1979 Enabling Clause decision (L/4903) which reduced the rules of Article XXIV to promote PTAs among developing countries provide for any sort of dispute mediation or resolution. They reinforce this point in Paragraph 12 of article XXIV which says that PTAs should try to enforce the agreements locally. The emphasis on local (and non-WTO) enforcement was reiterated in the 1994 Uruguay Round "Understanding" on the Interpretation of Article XXIV.

<sup>9</sup> For more on the negative club effects of antidumping claims see Blonigen and Bown (2003), Blonigen and Prusa (2003), Prusa (2001), and Prusa and Skeath (2004).

<sup>10</sup> For example, recent WTO administered disputes over bananas, foreign sales corporations, and the distribution of antidumping duties on steel were settled with the dispensation of only the offended party levying retaliatory tariffs for an indeterminate, but finite, period of time. Alternatively, Mercosur's newest incarnation of the "refrigerator war" has generated escalating rounds of reciprocal tariff increases by Argentina and Brazil. This escalation has occurred with the help of a new bilateral trade dispute resolution process entitled "Mechanism of Competitive Adaptation" that allows these two countries to review their disputes in a separate non-Mercosur proceeding.

<sup>11</sup> Stated by Marcos Jank of Sao Paulo's Institute for International Trade Negotiations (Clendenning, 2004).

<sup>12</sup> An additional difference that we do not consider here is that several PTAs such as the Andean pact, CACM, COMESA, the EFTA, and NAFTA allow private individuals to file claims which certainly must increase the potential for trade disputes.

This paper is most closely related to the literature on the hold-up problem in international trade and that on trade agreements. Lapan (1988) was the first to recognize that the optimal tariff after production has occurred is greater than the ex-ante optimal tariff. This time inconsistency problem in tariff setting can generate lower output levels and leave both countries worse off. In McLaren (1997), factor allocation precedes a trade agreement. Because governments can give side payments, agents do not internalize the erosion in national bargaining power caused by their actions. If free trade is expected, then factors will accumulate in the export sector causing an increase in the optimal tariff that can be levied against this country. In this case, the resulting side payment in the trade agreement may be so large as to leave the country worse off under an optimistic expectation of free trade than under an expectation of a trade war. Chisik (2003) does not allow for side payments as in McLaren (1997) and shows that this can cause countries to liberalize slowly, however, as the export capacity is developed over time countries become more integrated and trade barriers are gradually eroded. Hence, in the Chisik (2003) case the hold-up problem is gradually mitigated by successful past liberalizations. The introduction of imperfect observability, instability, and trade disputes, in this paper returns us to a form of the hold-up problem, however, it is imperfections in the potential solution (the trade agreement) that allows for the problem to occur. And in this case, it is not only export levels and tariffs that are distorted but also output quality and the degree of economic integration.

Mill (1844) is perhaps the first to consider the terms-of trade rational for trade agreements and Johnson (1953-1954) is the first formalization of this idea. Recognizing that there are no “blue helmets” to enforce trade agreements (Bello, 1996) authors such as Dixit (1987) and Bagwell and Staiger (1990, 1999, 2002) began to look at trade agreements as self-enforcing outcomes in a repeated game framework. Hungerford (1991), Riezman (1991), and Kovenock and Thursby (1992) also consider imperfect observability of trade barriers that could generate trade wars in equilibrium, however, their focuses are distinct and their papers differ from this one in several important respects. They do not consider production, irreversibility, or quality choice, and they only consider symmetric continuation payoffs. More recent work by Bagwell and Staiger (2005), Lee (2007), and Martin and Vergote (2008) consider trade disputes in equilibrium arising in frameworks with private information about domestic concerns and

political pressure. As a result of their focus on incomplete information, in a sense, their papers are more apt descriptions of safeguards brought under GATT articles XIX, XX, or XXVIII, rather than the article VI safeguards considered in this paper.<sup>13</sup> A larger distinction is that their focus is not on firm quality choice, irreversibilities, or integration. Furthermore, we make a distinction between available remedies in the WTO and their relative paucity in PTAs.

The next section describes the model and derives the inefficient equilibrium in the absence of a trade agreement. The third section considers our first two main results and considers the weak dispute settlement that is more typical of PTAs and unilateral actions. The fourth section considers how the WTO's strong dispute settlement can partially ameliorate the quality selection issue and it also helps to highlight the problem of selective misinterpretation of trade barriers. The fifth section contains our conclusions.

## 2. The Model

### *A. The Basic Setup*

We consider a repeated tariff setting game between the governments of two production economies with production irreversibilities. The competitive firms in each country produce a differentiated product for export and both produce a numeraire good which is traded to ensure trade balance.<sup>14</sup> The home country ( $x$ ) produces and exports good  $x$ , the foreign country ( $y$ ) produces and exports good  $y$ . Each export good can be further divided into quality levels. The value to consumers of good  $j$  in quality  $k$  is  $\theta_{jk}$ .

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<sup>13</sup> Martin and Vergote (2008) do consider antidumping, however, in their paper it arises from private political pressure and the desire to temporarily renegotiate the agreement as allowed for in Article XXVIII. In this paper, we are more concerned with abuse of Article VI that arises from imperfect rather than incomplete information.

<sup>14</sup> Irreversible production is more transparently analyzed with the inclusion of a numeraire good. The numeraire good is produced with the same constant returns to scale technology in both countries. The labor supply is assumed sufficiently large so that there is positive numeraire production in both countries and the wage is equal to the price of the numeraire good, which is normalized to one. Hence, the market value of the labor endowment is constant in all possible outcomes and is ignored.

The preferences of the identical agents, in each country, over consumption of the import goods and the numeraire can be represented by a quasilinear utility function.<sup>15</sup> Consumer utility maximization subject to their budget constraint yields demand functions  $D_{jk}^i(P_{jkt}^i) = \theta_{jk} - P_{jkt}^i$  where  $i \neq j$  and  $P_{jkt}^i$  is the consumer price in the importing country  $i$  for good  $jk$  in period  $t$ . We assume that consumers value higher quality so that  $\theta_{jk}$  is larger for higher quality. Note that we do not consider a country consuming its own export good. That is, we assume that markets are segmented, and we only consider the export market. Similarly, we assume that there is no import competing production. These two assumption have no effect on the results, however, it makes their derivation more transparent.<sup>16</sup>

In addition to the normalized price of the numeraire good, there are two exporter prices  $P_{ykt}^y, P_{xkt}^x$  and two importer prices  $P_{ykt}^x, P_{xkt}^y$  which are related by:

$$P_{ykt}^y = \varepsilon_t^x (P_{ykt}^x - \tau_{ykt}^x), \quad P_{xkt}^x = \varepsilon_t^y (P_{xkt}^y - \tau_{xkt}^y), \quad (1)$$

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<sup>15</sup> We can, therefore, restrict our analysis to the aggregate utility function. This utility function takes the following form:  $U^i(D_{jkt}^i, D_{zt}^i) = u^i(D_{jkt}^i) + D_{zt}^i$  for  $i \neq j$ . The sub-utility functions are quadratic  $u(D_{jkt}^i) = \theta_{jk}^i \cdot D_{jkt}^i - (D_{jkt}^i)^2 / 2$ . The large number of identical agents are each endowed with one unit of effective labor. These agents sell their labor to the firms and, as the firms' owners, they receive an equal share of the firms' profits. The agents also share equally any tariff revenue. There is no opportunity for saving and investment, and all agents are identical, therefore, there are no intertemporal or income distribution considerations, and the agents spend their entire income in every period on consumption of the firm's products. The strategic possibilities of the agents and firms are limited by their large numbers and are, therefore, ignored in the set of equilibria that we analyze below. Given the competitive behavior of the agents and the firms, each government chooses non-negative tariffs  $(\tau_t^x, \tau_t^y)$  to maximize national welfare over an infinite horizon.

<sup>16</sup> The assumption of segmented markets in trade models was first considered by Brander and Krugman (1983). Its simplicity makes it attractive. Our results do not in any way depend on this simplification, however, we employ it for the following two reasons. The most import reason is that the assumption of segmented markets allows us to return an important general equilibrium aspect to the model. Production irreversibility implies that increased output in one sector is potentially costly because it reduces future output in another sector, however, it affects export and import elasticities in a manner that necessitates a parameterization which does not afford a closed form solution in a traditional general equilibrium framework. In partial equilibrium this increased output comes from reduced output of the numeraire good so it is not directly experienced as a cost. The potential loss of profit during a trade war captures this loss, however, if the good is also consumed domestically, then the increased domestic consumption mitigates this loss. For the supply and demand functions give here, it is still a national welfare loss, however, its mitigation clutters the analysis. This increased domestic consumption is costless, however, only because of the perfectly elastic supply of labor that is available in the numeraire sector. Hence, by segmenting markets we eradicate the positive domestic consumption effect of increased output that is only possible because of a large numeraire sector (or equivalently, a large pool of qualified and unemployed labor). In a sense, the assumption of segmented markets here is like an application of Lipsey and Lancaster's (1956-1957) "Theory of the Second Best". Once we made one simplification by using a partial equilibrium economy it was better to make another simplification and segment markets. Second, and of lesser importance, is that as our model becomes more complex the stark representation of optimal tariffs with segmented markets makes it easier for the reader to follow.



or more succinctly as  $P_{jkt}^i = \varepsilon_t^i(P_{jkt}^i - \tau_{jkt}^i)$  where superscripts refer to countries and subscripts refer to goods. The random variables  $(\varepsilon_t^x, \varepsilon_t^y)$ , are induced by macroeconomic or preference fluctuations in the importing country, and reflect the noise inherent in observing a trade partner's policy. They are independently and identically distributed random variables with a unit mean and a non-negative support. The cumulative distribution functions  $F^i$  satisfy first-order stochastic dominance (FOSD) and the densities are defined over the full support of the distribution.

Governments negotiate over a combination of observable tariff and non-tariff barriers. We assume that the non-tariff barriers can be represented by means of an equivalent tariff and we use  $\tau_{jkt}^i$  to represent the sum of the direct and equivalent tariffs. Whereas tariffs are observable, non-tariff barriers are not all perfectly observable. The macroeconomic or preference fluctuations also indicate that these barrier choices cannot be perfectly inferred from price observations.<sup>17</sup> In fact, although governments know their own tariff choices, the entire past history of tariff choices is never perfectly observable. Hence, the tariff game between the governments is an infinitely repeated game of imperfect public information.

In what follows we simplify notation by writing  $\tau_{jkt}^{iE} = E[\tau_{jkt}^i]$  as the expected tariff levied by country  $i$ , where the expectation is taken with respect to the uncertainty regarding country  $i$ 's chosen tariff. We also write  $P_{jkt}^{jE} = E[P_{jkt}^j(\tau_{jkt}^{iE}, \varepsilon_t^j)] = E[\varepsilon_t^j(P_{jkt}^j - \tau_{jkt}^{iE})]$  where the expectation is with respect to the macroeconomic or preference fluctuation. Note as well that the expectation is unbiased, so that  $P_{jkt}^{jE} = P_{jkt}^j - \tau_{jkt}^{iE}$ . From this point forward we use the fact that the tariff of country  $i$  must be on good  $jk$  and drop these subscripts from the tariff notation.

In an initial period, the identical competitive firms choose a quality level and a maximum output level. Given that consumers and firms are identical all firms will independently choose the same quality

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<sup>17</sup> For notational simplicity we assume that the noise regarding the transparency of trade barriers and the macroeconomic or preference fluctuations is perfectly correlated and we write each producer price with a single noise term. As long they are not perfectly negatively correlated all of our results would still obtain with two types of noise affecting the realized producer price. Negative correlation would occur if governments tariffed their non-tariff barriers during recessions and reversed this tariffification during booms, however, there is no evidence of such a practice occurring and it is reasonable to expect that the noise terms are positively correlated.

level. Production of the non-numeraire goods is only partially reversible so that, in any period, firms can reduce output to  $\rho$  percent of the period 1 level.

$$Q_{jk} \geq Q_{jkt} \geq \rho_{jk} Q_{jk}, \text{ for all } t \quad (2)$$

where  $Q_{jkt}$  denotes output of quality  $k$  in sector  $j$  in period  $t$  and  $\rho_{jk}$  is the good specific measure of irreversibility. We use  $Q_{jk}$  to denote  $Q_{jkl}$ . Equation 2 indicates that output levels are bounded below by the firm's period 1 decision and by the given irreversibility parameter.<sup>18</sup>

This irreversibility assumption can be motivated by the need to develop and maintain networks and sales infrastructure in the importing country.<sup>19</sup> Higher quality products involve a more detailed and harder to learn production process and they may also require more export promotion, therefore, it is reasonable to assume that higher quality is correlated with greater irreversibility. Some of these expenses are sunk at the time of export expansion, however, many are also ongoing costs whose irreversibility stems from explicit contracts (such as advertising, brand name and sales infrastructure maintenance) and implicit contracts (such as maintaining networks and political favor). Roberts and Tybout (1997) and Das et al. (2007) provide evidence that, for Colombian firms, these costs are an important component of the decision to enter an export market. In this case  $\rho$  reflects the percentage of infrastructure that needs to be maintained even during a period of lower profitability. Irreversibility may also arise from the need to fit exports to the standards of the importing country (see, for example, Chen and Mattoo, 2006). It may also be interpreted as reflecting the reduced price that would be received if the exporter was forced to sell the goods at less preferential terms on the world market. Formally, we assume that  $\rho(\theta)$  is a strictly increasing function of  $\theta$ . Although quality is a continuous variable firms will be restricted to choosing either high or low quality. Hence, if  $\theta_{jh} > \theta_{jl}$ , then  $\rho_{jh} > \rho_{jl}$ . The high and low quality irreversibility realizations are naturally confined to the interval  $0 \leq \rho_{jk} \leq 1$  and for convenience we assume that the quality realizations lie in a bounded interval,  $\underline{\theta} \leq \theta_{jk} \leq \bar{\theta}$ .

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<sup>18</sup> Alternatively, we could consider the case whereby firms can remove a certain percentage every period, or remove it entirely after a delay, however, the more restrictive assumptions considered here, while not changing the results proves to be more tractable in the stochastic framework that we will consider below. Chisik (2003) and Chisik and Davies (2004) consider the alternative assumptions in deterministic frameworks in order to analyze the evolution of trade agreements and tax treaties.

<sup>19</sup> Alternatively, firms may have implicit contractual obligations with their workers or input suppliers arising from efficiency wage arrangements or explicit contractual obligations arising, for example, from union contracts.

Each firm within each country has the same strictly increasing and strictly concave production function which yields the strictly increasing and convex aggregate cost function  $C(Q_{jkt}) = Q_{jkt}^2/2$ . Note that the cost function is the same for either quality, therefore, firms will choose lower quality only as a result of irreversibility and frequent trade disputes. As mentioned above, we interpret the cost function as applying to export promotion and trade costs. We also assume a constant marginal production cost, that is normalized to zero.<sup>20</sup>

The equality between world demand and supply for each good combined with the pricing relationship in equation (1) defines the expected price of each good in each country as  $P_{jkt}^{iE} = P_{jkt}^i(\theta_{jk}, Q_{jkt}, \tau_t^{iE}) = \theta_{jk} - Q_{jkt}$  and  $P_{jkt}^{jE} = E[P_{jkt}^j(\theta_{jk}, Q_{jkt}, \tau_t^{jE}, \varepsilon_t^j) = \theta_{jk} - Q_{jkt} - \tau_t^{jE}]$ . The parameter  $\theta_{jk}$  can be interpreted as an index of the gains from trade that is provided by the quadratic utility and cost functions as the difference between the intercept of the supply and the demand functions. Given that the cost functions are the same for either quality, higher quality can be seen as a greater value in the index of gains from trade.

The preferences of the identical agents in each country can be represented by a social welfare function. The numeraire good provides an excess degree of freedom, therefore, in addition to requiring balanced trade we need to separately establish market clearing for each non-numeraire good in order to describe the equilibrium. Given that there is a partially irreversible production decision, equilibrium prices will be determined by the chosen maximum output levels as well as the tariffs and we can, therefore, write country  $i$ 's period  $t$  social welfare function as a function of these endogenous variables:  $V^i(\tau_t^{iE}, \tau_t^{jE}, Q_{ik}, Q_{jk})$ . Denoting  $\delta < 1$  as the discount factor, the expected present value of country  $i$ 's payoff in some period  $s$  of the repeated game is:

$$G^i = \sum_{t=s}^{\infty} \delta^{t-s} (E_{\varepsilon|s}[V^i(\tau_t^{iE}, \tau_t^{jE}, Q_{ik}, Q_{jk})]). \quad (3)$$

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<sup>20</sup> Identical cost functions for either quality allow us to see that the inefficient quality decision occurs only because of trade disputes and irreversibility. Alternatively, if higher quality has a higher cost, then it may have a lower production level, however, as long as it has greater irreversibility, then the results of the model would still obtain. Another possibility is that  $\theta$  is the same for either quality but that firms can lower their marginal cost by a constant amount, and that lower costs imply greater irreversibility. All of our results would obtain with this alternative formulation. They would also obtain whether we consider a specific tariff or an ad valorem tariff and whether the firms are competitive or collusive.

Per-period expected welfare can be represented as the aggregate indirect expected utility function.

It is the sum of expected consumer surplus, tariff revenue, and expected producer surplus:

$$\begin{aligned} E_{\varepsilon}[V^i(\tau_t^{iE}, \tau_t^{jE}, Q_{ik}, Q_{jk})] &= \int_{P_{jk}^i(\tau_t^i)}^{\theta} D_{jk}^i(P) dP + \tau_t^{iE} \cdot D_{jk}^i(P_{jk}^i(\tau_t^{iE})) + E_{\varepsilon}\left[\int_0^{P_{ik}^i(\tau_t^{jE})} Q_{ik}(P) dP\right] \\ &= \mu_i(Q_{jk}(\tau_t^{iE}), \tau_t^{iE}) + \tau_t^{iE} \cdot Q_{jk}(\tau_t^{iE}) + E_{\varepsilon}[r_i(Q_{ik}(\tau_t^{jE}), \tau_t^{jE})] \end{aligned} \quad (4)$$

where  $\mu_i(Q_{jk}(\tau_t^{iE}), \tau_t^{iE})$  is the expected maximized value of consumer utility,  $E_{\varepsilon}[r_i(Q_{ik}(\tau_t^{jE}), \tau_t^{jE})]$  is the firms' expected profits or losses and the middle term is tariff revenue. To unclutter the notation, from this point forward we will use that firms' expectation over their producer prices is unbiased and drop the expectation operator. Given that the observed producer price may differ from that implicitly chosen by the importing country government, we consider, in the following sections, the possibility that low observed producer prices may trigger a trade dispute. We also explain how ongoing disputes may end.

### B. Timing.

In the initial period, the competitive firms independently choose the level of quality and export promotion of their single export good. Governments then negotiate over a level of tariff bindings. The tariff binding is a cooperative tariff rate  $\tau^{ic}$  that indicates the maximum rate for the combination of the observable tariff and the tariff equivalent of the unobservable trade barriers. It will be seen below that both countries will raise tariffs to their binding during a cooperative phase. After tariff bindings are set firms in each country simultaneously choose output. Whereas output is unconstrained in the first period each further output decision is constrained as in equation (2). Next, outputs are revealed and governments set their tariff rates. Finally, prices are observed, and production and consumption take place. If the observed prices are below their trigger value, then a trade dispute starts in the following period. Trade disputes last at least one period, and they may continue indefinitely. Figure 1 describes the timing of the model for the simpler dispute settlement considered in the next section.

### C. Equilibrium during breakdown of a trade agreement.

We focus on the set of equilibria that can be supported by sequentially rational pure strategies. Following Abreu, Pearce, and Stacchetti (1990) the set of pure strategy sequential equilibria (PSE)

profiles  $\{\hat{\tau}_t^i, \hat{\tau}_t^j, \hat{Q}_{ik}, \hat{Q}_{jk}\}$  for this game can be described as the largest set which solves the following one period problem:

$$V(\hat{\tau}_t^i, \hat{\tau}_t^j, \hat{Q}_{ik}, \hat{Q}_{jk}) + G^i(\hat{\tau}_t^i, \hat{\tau}_t^j, \hat{Q}_{ik}, \hat{Q}_{jk}) \geq V(\tau_t^i, \tau_t^j, Q_{ik}, Q_{jk}) + G^i(\tau_t^i, \tau_t^j, Q_{ik}, Q_{jk}). \quad (5)$$

Equation (5) has two parts. The first part indicates that the payoff from following the equilibrium strategies in the current period plus the continuation payoff induced by those strategy choices is at least as great as any other feasible strategy choice. The second part indicates that the continuation payoffs are themselves a function of equilibrium strategy choices. In this way, the continuation payoffs are credible for they are also composed of PSE strategies.

As in a framework with fully reversible capacity, one PSE for this dynamic tariff game is an infinite repetition of the static Nash equilibrium. In this benchmark case, firms and governments expect a Nash tariff in every period ( $\tau_t^{iE} = \tau_t^{im}$ ) and firms choose the Nash capacity ( $Q_{jkt}^m$ ). A PSE in these Markovian strategies is a Markov-Perfect-Equilibrium (MPE). If output decisions are fully reversible, or if no output is ever planned, then the physical environment, as described by the state variable, would look the same to the firms and the governments in every period. The unique MPE in this case would be the infinite repetition of the static Nash equilibrium. The irreversible output indicates that histories with positive output may generate different MPE outcomes. We now characterize this MPE set.

**Proposition 1:** (i.) The unique MPE after a history with positive output is  $Q_{jkt}^m = \rho_{jk} Q_{jk} \geq 0$  and  $\tau_t^{iE} = \tau_t^{im}(Q_{jkt}) = P_{jkt}^{im}(\theta_{jk}, Q_{jkt}, 0) = \theta_{jk} - \rho_{jk} Q_{jk}$ .  
(ii.) The unique MPE after a history with no output is  $Q_{jkt}^m = 0$  and  $\tau_t^{im} = P_{jkt}^i(\theta_{jk}, 0, 0) = \theta_{jk}$ .

**Proof:** Each country's period-optimal tariff,  $\tau^m$ , satisfies the following first-order-condition:

$$\frac{\partial V^i(\cdot, \tau_{ik}^j, Q_{ik}, Q_{jk})}{\partial \tau_t^i} = D_{jk}^i(P_{jk}^i(\tau_t^{im}))[1 - P_{jk}^{i'}(\cdot)] + \tau_t^{im} \cdot D_{jk}^{i'}(\cdot) \quad (6)$$

We prove part (ii.) first. The maximum consumer price is  $P_{jk}^i(\theta_{jk}, 0, 0) = \theta_{jk}$ . Note that  $D_{jk}^i(P_{jk}^i(\tau_t^i)) \leq \theta_{jk}$  and it holds as an equality only if the consumer price is zero. There are two cases.

First, if  $\tau_t^{im} > P_{jk}^i(\theta_{jk}, 0, 0) = \theta_{jk} \geq D_{jk}^i(P_{jk}^i(\tau_t^{im}))$ , then because the producer price cannot be negative it must be the case that any increase in the tariff must be passed on to the consumers. Hence, to

preserve  $P_{jk}^j \geq 0$ , it must be that  $P_{jk}^{i'} = 1$  and then  $D_{jk}^{i'} = -1$ . From equation (6) we, therefore, see that if  $\tau_t^i > \theta_{jk}$  then  $\partial \mathcal{V}^i / \partial \tau_t^i < 0$  which is a contradiction. Second, suppose that  $\tau_t^{im} \leq P_{jk}^i(\theta_{jk}, 0, 0)$ , then any increase in the tariff will be passed on to the producers so that  $P_{jk}^{i'} = D_{jk}^{i'} = 0$ . From equation (6) we then have that  $\partial \mathcal{V}^i / \partial \tau_t^i > 0$  for  $\tau_t^i \leq \theta_{jk}$ , therefore, it is optimal to set  $\tau$  as high as possible or  $\tau_t^{im} = P_{jk}^i(\theta_{jk}, 0, 0)$ , which implies that  $P_{jk}^j = 0$ . Hence producers will choose  $Q_{jk} = 0$ .

For part (i.) we now consider the case when  $Q_{jk} > 0$ . The producer price must still be non-negative, so that  $P_{jk}^j \geq 0$ . The maximum consumer price is  $P_{jkt}^i(\theta_{jk}, Q_{jk}, 0) = \theta_{jk} - Q_{jkt}$ . There are again two cases to consider.

First, if  $\tau_t^{im} > P_{jkt}^i(\theta_{jk}, Q_{jk}, 0)$  then to preserve  $P_{jk}^j \geq 0$ , we have that  $P_{jk}^{i'} = 1$  and then  $D_{jk}^{i'} = -1$ . From equation (6) we, therefore, see that if  $\tau_t^{im} > P_{jkt}^i(\theta_{jk}, Q_{jk}, 0)$  then  $\partial \mathcal{V}^i / \partial \tau_t^i < 0$  which is a contradiction. Second, suppose that  $\tau_t^{im} \leq P_{jkt}^i(\theta_{jk}, Q_{jk}, 0)$ , then any increase in the tariff will be passed on to the producers so that  $P_{jk}^{i'} = D_{jk}^{i'} = 0$ . From equation (6) we then have that  $\partial \mathcal{V}^i / \partial \tau_t^i > 0$  for  $\tau_t^{im} \leq P_{jkt}^i(\theta_{jk}, Q_{jk}, 0)$ , therefore, it is optimal to set  $\tau$  as high as possible or  $\tau_t^{im} = P_{jkt}^i(\theta_{jk}, Q_{jk}, 0)$ , which implies that  $P_{jk}^j = 0$ . Producers will, therefore, choose  $Q_{jkt}^m = \text{Max}\{\rho_{jk} Q_{jk}, 0\} = \rho_{jk} Q_{jk}$ . Hence,  $\tau_t^{im} = \theta_{jk} - \rho_{jk} Q_{jk} = P_{jkt}^i$  and  $P_{jk}^j = 0$ .  $\square$

This result occurs because tariffs are chosen after output choices are made and, therefore, the elasticity of export supply is zero. In this case the optimal tariff would be infinite, however, the consumer price is bounded above (so that demand is equal to supply) and the expected producer price is bounded below by zero (because firms can choose not to sell if the price is negative). Hence, the exporter's expected price is zero and they will choose the smallest possible output:  $Q_{jkt}^m = \text{Max}\{\rho_{jk} Q_{jk}, 0\}$ . The tariff is such that the producer price is zero, therefore, the tariff is exactly equal to the consumer price that is necessary to clear the market:  $\tau_t^{im} = \theta_{jk} - \rho_{jk} Q_{jk} = P_{jkt}^i$ . Given the firms' export decisions, consumer surplus remains the same for any optimal tariff and, therefore, the Markov-Nash tariff will maximize tariff revenue and minimize expected producer revenue. Of course, foreseeing this situation, no firm would choose to export in the absence of some sort of trade agreement (whether explicit, as in this paper,

or implicit).<sup>21</sup> This stark outcome is a result of our assumption of segmented markets, and tariffs being chosen after output decisions are made.<sup>22</sup>

The best-response tariffs are not a function of the other country's tariff, therefore, they uniquely define the Markov-Nash-equilibrium tariffs. Notice as well that they are high enough to choke off all trade. This is an interesting component of the segmented market model with production irreversibility, where tariffs are chosen after production choices are made. In Dixit (1987) autarky is only an equilibrium in weakly dominated strategies and it only arises either because of the need for balanced trade without a numeraire good or the existence of export taxes. There is production irreversibility in Chisik (2003), however, the lack of segmented markets does not generate autarky (even in weakly dominated strategies). In the current framework, however, autarky is the unique MPE outcome and it requires both production irreversibility and segmented markets.

#### *D. Bilateral Trade Agreement Strategies*

We assume that the written trade agreement restricts the set of PSE profiles to those that are welfare maximizing for the two countries for a chosen set of continuation payoffs. We start by considering symmetric continuation payoffs and then we explain these symmetric strategies as being given by an institutional constraint and we then relax this constraint to consider welfare maximizing asymmetric trigger strategies. We refer to both sets of these profiles as trade agreement strategies, we use

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<sup>21</sup> It is possible that there is a unilateral agreement (implicit or otherwise) between the exporters and an importing country that permits a positive level of trade. In this agreement the only deterrence is that the exporters can reduce output if the importer raises its tariff; therefore, the importing government will not deviate if the extent of irreversibility is not too high or if the cooperative tariff is not too low. In a sense a bilateral trade agreement links the punishments in each of these unilateral trade agreements and, as in Bernheim and Whinston's (1990) analysis of multimarket contact, combining these two unilateral agreements generates stronger potential retaliation and permits a greater level of tariff reduction. I thank an anonymous referee for suggesting this line of reasoning.

<sup>22</sup> The main point of the paper is to address the trade agreement as opposed to the absence of the agreement and, therefore, these timing and segmented market assumptions (by yielding a simpler depiction of a trade war) afford a cleaner and more transparent representation of the analysis that follows without changing any of the results. For example, in Chisik (2003) markets are not segmented (and Markov-Nash tariffs do not reduce produce prices to zero), however, the same hold-up problem is evidenced; and, as in the current paper, it is only ameliorated through repeated interaction and history dependent strategies. Additionally, if tariffs are chosen before output, then, as long as there is production irreversibility, myopic governments would still exploit that irreversibility when choosing their Markov-Nash tariffs in the period following an irreversible output decision. Either of these alternative formulations would mildly complicate the algebra, but would not change any of the results.

the superscript  $c$  to denote their cooperative nature, and we drop the time subscript to indicate that they are the tariff bindings agreed to in the initial period:  $\{\tau^{ic}, \tau^{jc}, Q_{ik}^c, Q_{jk}^c\}$ .

In this uncertain environment low prices arise from unobserved tariff deviations or from macroeconomic or preference fluctuations. The imperfect tariff observability allows for countries to deviate from the agreement and blame the stochastic element. Hence, we consider trigger strategies. In particular, the trigger is given by  $\tilde{P} > 0$  and, therefore, the probability that the realization of the producer price  $P_{jt}^j$  is less than the trigger value for a country  $j$  export is  $\Pr(P_{jt}^j < \tilde{P}^j) = \Pr[\varepsilon_t^i(P_{jt}^i - \tau_t^i) < \tilde{P}^j] = F(\frac{\tilde{P}^j}{P_{jt}^i - \tau_t^i})$ . We denote  $1 - F(\frac{\tilde{P}^j}{P_{jt}^i - \tau_t^i}) = \varphi_j(\tau_t^i)$  as the cumulative probability that the producer price  $P_{jt}^j$  is greater than the trigger price  $\tilde{P}^j$  conditional on the chosen combined observable and unobservable tariff barriers  $\tau_t^i$ . By the FOSD of  $F^i$  we have that the conditional distribution  $\varphi_j(\tau_t^i)$  satisfies FOSD as well so that  $\varphi_j(\tau_t^i)$  is decreasing in  $\tau_t^i$ . To simplify notation we write  $\varphi_j(\tau^{ic}) = \varphi_j^c$ . The probability that both producer prices are above their trigger value, given that countries are adhering to the cooperative tariffs, is

$$\phi = \varphi_j^c \cdot \varphi_i^c = [1 - F(\frac{\tilde{P}^j}{P_{jt}^i - \tau_t^i})][1 - F(\frac{\tilde{P}^i}{P_{it}^j - \tau_t^j})]. \quad (7)$$

A dispute state is, therefore, signaled in period  $t$  (to start in  $t + 1$ ) with probability  $1 - \phi$ . If there is no uncertainty, so that the random variables  $\varepsilon_t^i = \varepsilon_t^j = 1$  for all  $t$ , then  $\varphi_j^c = \varphi_i^c = \phi = 1$ . Hence, we refer to  $\varphi_i^c$  as country  $i$ 's policy perception clarity and to  $\phi$  as a measure of trade stability.

Realized prices are bounded below by zero, therefore, the distributions  $F^i(\varepsilon^i)$  limit prices to be non-negative. A simple example of a distribution function that satisfies the above assumptions is where  $\varepsilon_t^i = (1/\chi)$  with probability  $\chi$  and  $\varepsilon_t^i = 0$  with probability  $1 - \chi$ . In this case the expected producer price is unbiased,  $P_{jkt}^{jE} = P_{jkt}^i - \tau_t^{iE}$  and the distribution  $\varphi_j(\tau^i)$  satisfies FOSD. A natural trigger price is  $\tilde{P}^j = \frac{1}{\chi}(P_{jt}^i - \tau_t^i)$ . Any tariff greater than the trade agreement tariff yields an observed price below the trigger price and triggers a trade war, therefore, in this case the optimal deviation is to the Markov-Nash tariff characterized in proposition 1. Note that for this distribution  $\varphi_j^c = \chi$ . Hence, when countries adhere to the trade agreement strategies a trade war will start in the next period with probability  $1 - \chi^2$ . If either country deviates, then a dispute is triggered with probability 1.



### 3. Weak Dispute Settlement

Our concept of weak dispute settlement (WDS) is adapted from Klimenko, Ramey, and Watson's (2008) idea of recurrent trade agreements. The idea is that countries agree to allow disputes to be settled by a third party that acts with some delay. By turning dispute settlement over to a third party countries effectively tie their hands with respect to renegotiation.<sup>23</sup> In WDS the trade authority does not discern which country is more likely to have deviated from the agreement. When a dispute flares up, both countries simultaneously suspend previously granted concessions and enter a trade war phase. In the trade war both countries act in their own short-term self-interest, knowing that their actions will be ignored once the dispute is settled. Hence, both countries levy Nash tariffs. These symmetric punishments are typical of the trade disputes that are evidenced in many PTAs. For countries to be willing to forego the possibility of renegotiation the dispute must be finite. The recurrent trade agreement strategies of Klimenko et al are not developed for the non-symmetric case or for the imperfectly observable tariffs that we consider here, therefore, our WDS trade agreement strategies should be considered as being in the spirit of their proposed recurrent trade agreement strategies.

Weak dispute resolution is, therefore, a delay in re-administering previously allowed concessions. If the countries are in a trade dispute in period  $t$ , then the probability that the dispute settlement is effective and they resolve the dispute by period  $t + 1$  is given by  $\pi$  so that with probability  $(1 - \pi)$  the countries remain in a trade dispute in the following period.<sup>24</sup> These WDS trade agreement strategies are straightforward. If the trade agreement has been adhered to in the past, and no external shock in the previous period triggers a withdrawal of concession stage or if the countries are in a withdrawal of concession stage and the dispute is settled, then the home country sets its current tariff according to the trade agreement. After any other history they are in a withdrawal of concession stage awaiting a dispute settlement. Firms have similar strategies. If the countries are not in a dispute stage in period  $t$  and if there is no indication that either government intends to deviate from the treaty in the current period, then firms

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<sup>23</sup> Adapting the spirit of recurrent trade agreements for our WDS case is useful in several ways. First, it allows for a concise presentation of sequential equilibrium strategies in a repeated game of imperfect public information (where temporary punishments strictly dominate infinite trade disputes). Second, they provide a straightforward transition to the next section where we consider strong dispute settlement.

<sup>24</sup> We could also allow for finite and knowable delays so that the dispute is settled after  $T$  periods.

produce according to the expected tariff. A representation of the timing of the model that also takes into account the possibility of trade wars and their settlement is given in figure 1.

#### A. WDS Payoff Functions

We are interested in describing three different stage game outcomes. When both countries abide by the trade agreement, firms expect a cooperative tariff and the payoff in period  $t$  can be written as

$$V_t^{ic}(\tau^{ic}, \tau^{jc}) = V_t^{ic}(\tau^{ic}, \tau^{jc}, Q_{ik}(\tau^{jc}), Q_{jk}(\tau^{ic})) = \mu_i(Q_{jk}(\tau^{ic}), \tau^{ic}) + r_{ik}(Q_{ik}(\tau^{jc}), \tau^{jc}) + \tau^{ic} \cdot Q_{jk}(\tau^{ic}).$$

If deviating from the agreement in period  $t$ , then the optimal deviation is given by  $\tau_t^{id} = \tau_t^{id}(Q_{jk}(\tau^{ic}))$ .

The quantities are still set at the cooperative levels. Hence, the deviating payoff can be written as

$$V_t^{id}(\tau^{ic}, \tau^{jc}) = V_t^{id}(\tau_t^{id}, \tau^{jc}, Q_{ik}(\tau^{jc}), Q_{jk}(\tau^{ic})) = \mu_i(Q_{jk}(\tau^{ic}), \tau_t^{id}) + r_{ik}(Q_{ik}(\tau^{jc}), \tau^{jc}) + \tau_t^{id} \cdot Q_{jk}(\tau^{ic}).$$

The optimal deviation may be less than the Markov-Nash tariff, because a reduced deviation also reduces the probability of starting a trade dispute. If a deviation is perfectly observed (as in the example in the last paragraph of section 2.D.), then the optimal deviation is equal to the Markov-Nash tariff. We only assume that the optimal deviation tariff is such that it does not decrease too rapidly along with the chosen quantity:  $\partial \tau_t^{id} / \partial Q_{jk}(\tau^{ic}) > -2$ . (This condition is easily satisfied, for example, when  $\tau_t^{id} = \tau_t^{im}$ .)

During a trade war, both countries levy Markov-Nash tariffs and reduce their capacity so that the trade war payoff can be written as

$$V_t^{iw}(\tau^{ic}, \tau^{jc}) = V_t^{iw}(\tau_t^{im}, \tau_t^{jm}, \rho_{ik} Q_{ik}(\tau^{jc}), \rho_{jk} Q_{jk}(\tau^{ic})) = \mu_i(\rho_{jk} Q_{jk}(\tau^{ic}), \tau_t^{im}) + r_i(\rho_{ik} Q_{ik}(\tau^{jc}), \tau_t^{jm}) + \tau_t^{im} \cdot \rho_{jk} \cdot Q_{jk}(\tau^{ic}),$$

where  $\tau_t^{im} = \tau_t^{im}(\rho_{jk} Q_{jk}(\tau^{ic}))$ . We denote  $Q_{ik}^c = Q_{ik}(\tau^{jc})$  and  $r_t^{ic} = r_i(Q_{ik}^c, \tau_t^{jc})$ , respectively, as the firm's chosen quantity and expected profits when expecting a cooperative tariff. Similarly,  $Q_{ikt}^m = \rho_{ik} Q_{ik}(\tau^{jc}) = \rho_{ik} Q_{ik}^c$  and  $r_t^{im} = r_i(Q_{ikt}^m, \tau_t^{jm})$  are the chosen quantity and expected (negative) profit when facing a Markov-Nash tariff. Writing the expected cooperative price as  $P_{ikt}^{ic} = P_{ikt}^i(\theta_{ik}, Q_{ik}, \tau^{jc})$  we have that  $r_t^{ic} = P_{ikt}^{ic} Q_{ik}^c - (Q_{ik}^c)^2 / 2$  and  $r_t^{im} = -(Q_{ikt}^m)^2 / 2 = -\rho_{ik}^2 (Q_{ik}^c)^2 / 2$ . Similarly,  $\mu_i^c = \mu_i(Q_{jk}^c, \tau^{ic}) = (Q_{jk}^c)^2 / 2$ . Using Proposition 1, we have  $\mu_i^w = \mu_i(\rho_{jk} Q_{jk}^c, \tau^{im}) = (\rho_{jk} Q_{jk}^c)^2 / 2$  and that  $\mu_i^c = \mu_i^d$ . We derive  $Q_{ik}^c$  in equation (11) below.

Given the WDS trade agreement strategies, the value of abiding by the agreement in some period  $t$  is given by:

$$G^{ic} = V^{ic} + \delta(\phi G^{ic} + (1 - \phi)[V^{iw} + \delta(\pi G^{ic} + (1 - \pi)G^{iw})]).$$

Note how we have relied upon the recursive structure of the model after the initial capacity choice. The value of the withdrawal of concession stage also affords a recursive representation and is given by:

$$G^{iw} = V^{iw} + \delta(\pi G^{ic} + (1 - \pi)G^{iw})$$

Solving these two equations simultaneously yields:

$$G^{ic} = \frac{(1 - \delta(1 - \pi))V^{ic} + (1 - \phi)\delta V^{iw}}{1 - \delta(1 + \phi - \pi) + \delta^2(\phi - \pi)}; \quad (8)$$

$$G^{iw} = \frac{\delta\pi V^{ic} + [1 - \delta\phi]V^{iw}}{[1 - \delta(1 + \phi - \pi) + \delta^2(\phi - \pi)]}. \quad (9)$$

We write  $\zeta = 1 - \delta(1 + \phi - \pi) + \delta^2(\phi - \pi) = [1 - \delta(\phi - \pi)][1 - \delta]$  and we note that  $\zeta \in (0, 1)$ .

Note that in the absence of uncertainty (when  $\phi = 1$ ) the expression for  $G^{ic} = V^{ic}/(1 - \delta)$ .

### B. Firms

The expected discounted value of current and future profits for a firm, given that countries are abiding by the trade agreement is given by  $R^{ic} = r^{ic} + \delta(\phi R^{ic} + (1 - \phi)[r^{im} + \delta(\pi R^{ic} + (1 - \pi)R^{iw})])$ . The expected discounted value in a withdrawal of concession stage is  $R^{iw} = r^{im} + \delta(\pi R^{ic} + (1 - \pi)R^{iw})$ .

Solving these simultaneously we have

$$R^{ic} = \frac{(1 - \delta(1 - \pi))r^{ic} + (1 - \phi)\delta r^{im}}{\zeta} \text{ and } R^{iw} = \frac{\delta\pi r^{ic} + [1 - \delta\phi]r^{im}}{\zeta} \quad (10)$$

Maximizing  $R^{ic}$  with respect to  $Q$  for the competitive firms (taking price as given) yields the competitive quantity chosen in anticipation that countries will abide by the agreement:

$$Q_{ik}^c = \frac{(1 - \delta(1 - \pi))(\theta_{ik} - \tau^{jc})}{(1 - \delta(1 - \pi))2 + (1 - \phi)\delta\rho_{ik}^2} = \frac{\gamma(\theta_{ik} - \tau^{jc})}{2\gamma + \nu_i} \quad (11)$$

where  $\gamma = 1 - \delta(1 - \pi)$  and  $\nu_i = (1 - \phi)\delta\rho_{ik}^2$ . It is interesting to note that if  $\phi = 1$  (or  $\delta$  or  $\rho = 0$ ), then  $Q_{ik}^c = \frac{\theta_{ik} - \tau^{jc}}{2}$  which would be the standard case where there is no uncertainty or irreversibility or firms

do not care about the future. It is straightforward to verify that  $Q_{ik}^c$  is increasing in  $\theta$ ,  $\phi$  and  $\pi$  and decreasing in  $\tau$  and in  $\rho$ .

$$\begin{aligned}
\frac{1}{2} > \frac{\partial Q_{ik}^c}{\partial \theta_{ik}} &= \frac{\gamma}{2\gamma + v_i} > 0 > \frac{\partial Q_{ik}^c}{\partial \tau^{jc}} = \frac{-\gamma}{2\gamma + v_i} > -\frac{1}{2}; \frac{\partial Q_{ik}^c}{\partial \phi} = \frac{\gamma \delta \rho_{ik}^2 (\theta_{ik} - \tau^{jc})}{(2\gamma + v_i)^2} > 0; \\
\frac{\partial Q_{ik}^c}{\partial \pi} &= \frac{v_i \delta (\theta_{ik} - \tau^{jc})}{(2\gamma + v_i)^2} > 0 > \frac{\partial Q_{ik}^c}{\partial \delta} = \frac{-(1-\phi) \rho_{ik}^2 (\theta_{ik} - \tau^{jc})}{(2\gamma + v_i)^2} < 0; \text{ and} \\
\frac{\partial Q_{ik}^c}{\partial \rho_{ik}} &= \frac{-2\gamma(1-\phi) \delta \rho_{ik} (\theta_{ik} - \tau^{jc})}{(2\gamma + v_i)^2} < 0
\end{aligned} \tag{12}$$

The upper and lower bounds on  $\frac{\partial Q_{ik}^c}{\partial \theta_{ik}}$  and  $\frac{\partial Q_{ik}^c}{\partial \tau^{jc}}$  will prove useful below. Note, as well, that

$Q_{ik}^c < (\theta_{ik} - \tau^{jc})/2$ . It will also be helpful to assume that  $\pi + \phi$  are not too low.

$$\pi + \phi > 2 - 1/\delta \tag{13}$$

This assumption is weakly sufficient for some of the following results, however, it allows a more intuitive presentation. The assumption says that if the countries adhere to the trade agreement strategies and if they care enough about the future, then the probability of avoiding a trade war and the probability of ending a trade dispute are not too low. It is sufficient for them to add up to one, however, that is not necessary. For example if  $\delta \leq 1/2$ , then the assumption is not at all restrictive. Furthermore, note that (13) implies that  $\gamma > v_i$ .

### C. Quality Choice

Inserting  $Q_{ik}^c$  into the expressions for  $r^{jc}$  and  $r^{jm}$  and then substituting these resulting equations into  $R^{ic}$  we see that the partial derivative of  $R^{ic}$  with respect to  $\theta$  is positive and with respect to  $\rho$  is negative. Noting the relationship between  $\rho$  and  $\theta$  we have that the sign of the total effect of  $\theta$  on  $R^{ic}$  depends on how fast  $\rho$  is increasing in  $\theta$  and on the measure of trade stability. If  $\rho'(\theta)$  is large, then the loss is larger during a trade war, and if  $\phi$  is low, then there is a greater chance of a war. Hence, if irreversibility or uncertainty is greater, then firms are more likely to choose low quality, even though high quality has the same production cost and consumers will pay more for it. Formally, we note that for every realization of high and low quality valuations  $\{\theta_{ih}, \theta_{il}\}$  and low-quality irreversibility  $\{\rho_{il}\}$ , there is a  $\rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$  such that if high-quality irreversibility is higher than  $\rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$ , then firms will choose low quality. Hence,  $1 - \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$  is the measure of high-quality irreversibility realizations that cause

firms to choose low quality. We now show that  $1-\rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$  has positive measure if and only if  $\phi < 1$  and that  $1-\rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$  is decreasing in  $\phi$ .

**Proposition 2:** (i.) *If there is uncertainty ( $\phi < 1$ ), then there is a positive measure of realizations for high-quality irreversibility such that firms will choose lower quality.*

(ii.) *If there is no uncertainty ( $\phi = 1$ ), then firms will choose high quality.*

(iii.) *Firms are more likely to produce lower quality when uncertainty is large ( $\phi$  is small) or irreversibility is increasing rapidly in quality ( $\rho'(\theta)$  is large).*

**Proof:** We proceed in three steps. First we show that  $R_k^{ic}$  is increasing in  $\theta_{ik}$  and decreasing in  $\rho_{ik}$ . Next we show that it is supermodular in  $\theta_{ik}$  and  $-\rho_{ik}$  so that more irreversibility reduces the marginal benefit of greater gains from trade. Finally we show that irreversibility has no effect when there is no uncertainty and that the effect of irreversibility is increasing in the measure of instability.

$$\frac{\partial R^{ic}}{\partial \theta_{ik}} = \frac{[1-\delta(1-\pi)]^2 [1-\delta(1-\pi) + (1-\phi)\delta\rho_{ik}^2](\theta_{ik} - \tau^{jc})}{[1-\delta(\phi-\pi)][1-\delta][1-\delta(1-\pi)2 + (1-\phi)\delta\rho_{ik}^2]^2} = \frac{\gamma^2[\gamma + \nu_i](\theta_{ik} - \tau^{jc})}{\zeta[2\gamma + \nu_i]^2} > 0. \quad (14)$$

$$\frac{\partial R^{ic}}{\partial \rho_{ik}} = \frac{-\gamma^2[(1-\phi)^2\delta^2\rho_{ik}^3](\theta_{ik} - \tau^{jc})^2}{\zeta[2\gamma + \nu_i]^3} < 0. \quad (15)$$

$$\frac{\partial^2 R^{ic}}{\partial \rho_{ik} \partial \theta_{ik}} = \frac{-\gamma^2[(1-\phi)^2\delta^2\rho_{ik}^3]2(\theta_{ik} - \tau^{jc})}{\zeta[2\gamma + \nu_i]^3} < 0. \quad (16)$$

$$\frac{\partial^2 R^{ic}}{\partial \theta_{ik} \partial \phi} = \frac{[\nu_i\delta\rho_i^2\mu + (2\gamma + \nu_i)(\gamma + \nu_i)\delta(1-\delta)]\gamma^2(\theta_{ik} - \tau^{jc})}{\zeta^2[2\gamma + \nu_i]^3} > 0 \quad (17)$$

$$\frac{\partial^2 R^{ic}}{\partial \rho_{ik} \partial \phi} = \frac{\gamma^2[(1-\phi)\delta^2\rho_{ik}^3](1-\delta)(\theta_{ik} - \tau^{jc})^2}{\mu^2[2\gamma + \nu_i]^4} [(4-2\delta\phi+4\delta\pi-2\delta)\gamma - (1-2\delta\phi+\delta\pi+\delta)\nu_i] > 0. \quad (18).$$

From equation (16) we know that two graphs of  $R^{ic}(\theta_{ik})$  that differ in their value of  $\rho_{ik}$  can cross only once. From equations (10) and (11) we know that they must cross at  $\theta_{ik} = 0$ . Hence, for any  $\rho_{ik}$  there exists a  $\theta(\rho_{ik})$  such that if  $\rho_{ih} > \rho_{il}$ , then  $\theta(\rho_{ih}) > \theta(\rho_{il})$ ; and for all  $\theta_{ik}$  such that  $\theta(\rho_{il}) < \theta_{ik} < \theta(\rho_{ih})$  it is the case that  $R^{ic}(\theta_{ik}, \rho_{il}) > R^{ic}(\theta(\rho_{ih}), \rho_{ih})$ . This establishes that firms would choose the quality indexed by  $(\theta_{ik}, \rho_{il})$  over the quality indexed by  $(\theta(\rho_{ih}), \rho_{ih})$  even when  $\theta(\rho_{ih}) > \theta_{ik}$ . This relationship is shown in figure 2. Hence, if  $\phi < 1$ , then for any realization of  $\{\theta_{ih}, \theta_{il}, \rho_{il}\}$  there is a  $\rho^W(\theta_{ih}, \theta_{il}, \rho_{il}) < 1$  such that for all  $\rho_{ih} > \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$  firms will choose low quality. This establishes part (i.) that  $1 - \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$  has positive measure.

In addition, note that if  $\phi = 1$ , then equation (14) still has the same sign, but equations (15) and (16) are both identically zero. Hence, if there is no uncertainty, and trade wars are not begun when countries use trade agreement strategies, then irreversibility has no deleterious effect on quality choice. This establishes part (ii.) that  $1 - \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$  has positive measure only if  $\phi < 1$ .

To establish part (iii.) note that equation (17) shows that more stability increase the slope of  $R^{ic}$  with respect to  $\theta_{ik}$  and equation (18) shows that greater stability reduces the negative effect of irreversibility. (The assumption in (13) is used for determining the sign of equation (18) and is weakly sufficient for that result.) Finally, from equation (18) it is straightforward to see that

$$\frac{\partial^3 R^{ic}}{\partial \theta_{ik} \partial \phi \partial \rho_{ik}} = \frac{2}{\theta_{ik} - \tau^{jc}} \frac{\partial^2 R^{ic}}{\partial \rho_{ik} \partial \phi} > 0$$

so that the effect in equation (17) is more pronounced when there is more irreversibility. Hence, for any  $\rho_{ih} > \rho_{il}$ , the distance between  $\theta(\rho_{ih})$  and  $\theta(\rho_{il})$ , is decreasing in  $\phi$ . Similarly,  $\rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$  is increasing in  $\phi$  so that the measure of high quality irreversibility realizations that generate inefficient low-quality choices is decreasing in  $\phi$ .  $\square$

The essence of Proposition 2 is illustrated in Figure 2. We see there that profits are increasing in quality, but they are increasing more slowly if irreversibility is greater. Hence, if trade wars happen with enough frequency, then firms may choose lower quality only because its output is more easily reversible.

The intuition behind Proposition 2 can be seen by totally differentiating  $R^{ic}$  with respect to  $\theta_{ik}$  which yields:  $\frac{dR^{ic}}{d\theta_{ik}} = \frac{\partial R^{ic}}{\partial \theta_{ik}} + \frac{\partial R^{ic}}{\partial \rho_{ik}} \frac{d\rho_{ik}}{d\theta_{ik}}$ . Rearranging shows that if the elasticity of  $\rho_{ik}$  with respect to  $\theta_{ik}$ ,

$$\frac{d\rho_{ik}}{d\theta_{ik}} \frac{\theta_{ik} - \tau^{jc}}{\rho_{ik}} > \frac{2\gamma^2 + 3\gamma\nu_i + \nu_i^2}{\nu_i^2}, \quad (19)$$

then  $\frac{dR^{ic}}{d\theta_{ik}} < 0$ . It is straight forward to verify that the right-hand side of the equation (19) is increasing in

$\phi$ , so that an increase in trade stability makes it less likely firms will choose lower quality. On the other hand, when  $\rho_{ik}$  is increasing rapidly with  $\theta_{ik}$ , then firms will choose lower quality and this effect is stronger when  $\phi$  is lower.

An interesting empirical prediction that stems from Proposition 2 is that trade would be reduced more during each trade war when trade wars are more frequent. In particular, more frequent trade

disputes increase the measure of high-quality irreversibility realizations such that firms will choose low quality when it is more easily reversible. When output is more reversible, trade is reduced more during a trade war.

**Proposition 3:** *An increase in the probability, or frequency, of trade disputes weakly generates more trade reduction during each trade dispute.*

**Proof:** From Proposition 2 we know that more frequent trade disputes (a lower value of  $\phi$ ) increase the benefit of choosing lower quality only because its output is more readily reversible (a lower value of  $\rho$ ). Hence, the chosen level of irreversibility is weakly decreasing in the probability of a trade dispute. From Proposition 1 we see that a lower  $\rho$  means that trade will be reduced by a greater percentage during a trade war.  $\square$

An additional interesting corollary of proposition 2 is that countries with less stable economies (or governments) may end up producing lower quality. This is because macroeconomic instability impinges on the ability to accurately observe trade policies and in this framework trade disputes are only triggered more often when observability is worse. In addition, it suggests that the trading partner's macroeconomic stability and tariff observation clarity may affect the quality decision. Furthermore, if a trade relationship developed during periods when exporters expected stability (at home or abroad), then those exporters would have been more willing to devote the necessary resources to develop higher quality goods even if those goods had greater irreversibility. Hence, even if two countries face similar levels of current trade stability, initially differing levels may explain current quality choices.

An additional empirical prediction could be made with respect to changing trade patterns during trade disputes. If a country developed goods with greater gains from trade that were more irreversible, then during a trade dispute they would not be able to reduce output as much and would choose to export to third markets rather than suffer losses by exporting to the country that is levying the high tariff. This idea of trade deflection was first introduced by Bown and Crowley (2007). The model in this paper would predict more trade deflection for countries that produce high quality goods and, therefore, for

countries that industrialized in a period of expected trade stability. On the other hand, countries that industrialized while facing many changing and restrictive trade measures by their trading partners would produce lower-quality, more easily reversible, output and would simply reduce output and would not deflect trade to third countries. Interestingly enough, whereas Bown and Crowley (2007) found evidence of trade deflection for Japan, in a related study (Bown and Crowley, 2010) they found no such evidence for China. These differing cases could be explained by the mechanism in this paper.

#### D. The Trade Agreement Tariffs

Given the trade agreement strategies, cooperating yields an expected current and continuation payoff of  $V^{ic} + \delta[\phi G^{ic} + (1 - \phi)G^{iw}]$ . On the other hand, given the FOSD of  $\varphi_j(\tau_i^j)$ , a deviating tariff of  $\tau^{id}$  reduces  $\varphi_j(\tau^{ic})$  to  $\varphi_j(\tau^{id})$ . Denote  $\phi^{id} = \varphi_i(\tau^{ic}) \cdot \varphi_j(\tau^{id})$  as the probability that neither producer price triggers a trade war, given that country  $i$  chose a deviating tariff. A deviation, therefore, yields expected current and continuation payoffs of  $V^{id} + \delta[\phi^{id} G^{ic} + (1 - \phi^{id})G^{iw}]$ . The one period gain from deviating in period  $t$  can be written as

$$\Psi_t^i = V_t^{id} - V_t^{ic} \quad (20)$$

This gain must be balanced against the cost of a future trade war:

$$\Omega_t^i = \delta(\phi - \phi^{id})(G^{ic} - G^{iw}) = \Delta(\phi, \pi, \delta)(V_t^{ic} - V_t^{iw}) \quad (21)$$

where  $\Delta(\phi, \pi, \delta) = \frac{\delta(\phi - \phi^{id})}{1 - \delta(\phi - \pi)} > 0$ . It is straightforward to verify that  $\Delta$  is increasing in  $\delta$  and in  $\phi$  and is

decreasing in  $\pi$ . Note as well that  $\phi - \phi^{id}$  is non-negative and non-decreasing in  $\tau^{id}$ .

The trade agreement is described by tariff bindings  $\{\tau^{ic}, \tau^{jc}\}$  that maximize

$$\sum_{i \in \{X, Y\}} G^{ic}(\mathcal{Q}_{ik}^c, \mathcal{Q}_{jk}^c, \tau^{ic}, \tau^{jc}) \quad (22)$$

subject to the constraint that the chosen cooperative tariffs and resulting capacity choices do not cause the gain from deviating from the agreement to be greater than the cost of a future trade war.

$$\Psi_t^i \leq \Omega_t^i, \quad i \in \{x, y\}, \forall t. \quad (23)$$

It is straightforward to verify that world welfare (as defined by equation 22), is a strictly decreasing function of the tariff rates (if the countries are not too asymmetric) and, therefore, is maximized by free trade. The trade agreement, therefore, specifies the lowest tariff that satisfies the



incentive constraint given by equation (23). Note that when the countries differ the incentive constraint will be binding at different tariffs for each country.

#### *E. The gains from a Trade Agreement*

We graph country  $i$ 's incentive constraint as a function of  $\tau^{ic}$  in figure 3. In the proof to the following proposition we show that  $\Psi_t^i$  is strictly decreasing in  $\tau^{ic}$  and that  $\Omega_t^i$  is strictly concave in  $\tau^{ic}$ . Furthermore, we show that  $\Omega_t^i$  crosses  $\Psi_t^i$  from above as  $\tau^{ic}$  approaches  $\tau_1^{im}$ . Hence, it must be the case that  $\Omega_t^i$  crosses  $\Psi_t^i$  from below at some  $\tau^{ic}$  less than  $\tau_1^{im}$ . The agreement is self-enforcing for all  $\tau^i$  in this range and chooses  $\tau^{ic}$  as the lowest  $\tau^i$  in this interval.

**Proposition 4:** *There exists a connected set of non-prohibitive self-enforcing tariffs that are strictly less than the Markov-Nash tariff.*

The proof of Proposition 4 is contained in the appendix. The basic idea of the proof is outlined above where we describe the shape of the incentive constraint with respect to  $\tau^{ic}$ .<sup>25</sup>

#### *F. Economic Integration*

When a country's own export good offers more gains from trade or has more irreversible production that country will be more dependent on the trade relationship. This dependence relaxes the incentive constraint so that the country will offer greater tariff concessions on their import good. The following proposition develops this idea of increasing integration between the countries.

**Proposition 5:** *A country will offer greater tariff concessions ( $\tau^{ic}$  lower), if their own export good is higher quality and generates greater gains from trade ( $\theta_{ik}$  higher). This effect is more pronounced if the degree of irreversibility is increasing faster in quality ( $\rho'(\theta_{ik})$  higher).*

The proof of proposition 5 is contained in the appendix. The essence of the proof is shown in Figures 4 and 5. In Figure 4 we see that greater gains from trade on a country's export good increases the

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<sup>25</sup> Although we show that  $\Psi$  is strictly decreasing we do not claim that it is strictly convex. We only draw it that way for convenience. Still, if the optimal deviation is equal to the Markov-Nash tariff, then  $\Psi$  is strictly convex.

discounted future cost of a current period deviation and, therefore, lowers the lowest self-enforcing tariff that a country would charge on its import good. A similar result is obtained for an increase in the degree of irreversibility and that is shown in Figure 5.

Proposition 5 is important because it illustrates the concept of economic integration that occurs in trade agreements. If exporters choose a good with more gains from trade and more irreversibility, then they would suffer more from a temporary suspension of trade concessions. In this case the countries are more integrated and can enforce lower trade agreement tariffs.

#### **4. Strong Dispute Settlement and Asymmetric Continuation Payoffs.**

We now consider dispute settlement that makes careful use of the information in the public outcome. In particular, the interaction in this paper can be described as a game that has a product structure (Fudenberg et al., 1994, p. 1027). The outcomes  $\{P_{jkt}^j, P_{ikt}^i\}$  are statistically independent and depend only on the actions of player  $i \neq j$ . In this case a greater level of cooperation can be enforced if the country that is more likely to have deviated is also more likely to suffer during a dispute. As Abreu et al (1990) show, optimal continuation payoffs take a bang-bang structure. Hence, if only country  $j$ 's producer price is low enough to trigger a dispute, then country  $i$  is more likely to have deviated and, therefore, they should be the only country to suffer during a dispute.

We refer to this use of information as Strong Dispute Settlement (SDS). It is straightforward to verify that SDS combined with asymmetric continuation payoffs can yield a greater level of cooperation. In this framework greater cooperation implies that free trade is supportable for a wider range of discount factors. If free trade is not supportable, then lower tariffs are enforceable. The level of cooperation, however, is still dependent on the levels of output and irreversibility.

In addition to extending the results of Abreu et al. (1990) and Fudenberg et al. (1994) to this tariff setting framework with production irreversibility we show that SDS with asymmetric continuation payoffs can mitigate the quality choice problem. The application to trade agreements is particularly apt because PTAs have very limited or non-existent dispute settlement procedures as compared to those available in the WTO. In addition, the WTO has an investigative authority that has the knowledge and

ability to recommend asymmetric rewards and punishments. Hence, we can think of WDS as the norm in PTAs or antidumping club filings and SDS as the rule in the WTO.

#### A. Strong Dispute Settlement Payoffs

The timing of the SDS regime is as follows. The first part of the timing, until a trade dispute is triggered, mirrors the WDS regime and is described on page 11.

After prices are observed there are four possibilities when countries are adhering to the SDS trade agreement strategies. First, with probability  $\varphi_j^c \varphi_i^c$  both producer prices are above their trigger value and the next period is again cooperative. Second, with probability  $\varphi_j^c (1 - \varphi_i^c)$  the producer price in country  $i$  is below its trigger value. In this case country  $i$  can retaliate with the Markov-Nash tariff and country  $j$  must levy the cooperative tariff. With probability  $\pi$  dispute settlement is effective and with probability  $\varphi_i^c$  the producer price in country  $i$  is above its trigger value (so that country  $j$  is believed to abide by their punishment), therefore, the dispute is resolved and the next period is cooperative. Conversely, with probability  $(1 - \pi) + \pi(1 - \varphi_i^c)$  the countries continue with the punishment of country  $j$  in the following period. Third, with probability  $\varphi_i^c (1 - \varphi_j^c)$  the producer price in country  $j$  is below its trigger value and country  $j$  retaliates, which mirrors the second case. Fourth, with probability  $(1 - \varphi_j^c)(1 - \varphi_i^c)$  both prices are below their trigger value. In this case there is bad news about both countries and either or both could suffer punishment. If both countries levy Nash-tariffs, then we are in the previous WDS trade war stage, which is clearly inefficient. If, instead, only one country suffers the punishment stage but the recipient is selected at random, then there is no enforcement reduction, and expected payoffs are higher. In this case, with probability  $1/2$ , country  $i$  will be the retaliator and with probability  $1/2$  they will be punished. After the retaliator and punished are selected at random the game proceeds as in the second or third case.

The cooperative stage is defined as before.

$$V_t^{ic}(\tau^{ic}, \tau^{jc}) = v_i(Q_{jk}(\tau^{ic}), \tau^{ic}) + r_{ik}(Q_{ik}(\tau^{jc}), \tau^{jc}) + \tau^{ic} \cdot Q_{jk}(\tau^{ic}).$$

With probability  $\varphi_j^c (1 - \varphi_i^c)$  country  $i$  will receive a producer price low enough to trigger retaliation.

Country  $i$  can retaliate with a Nash-tariff while country  $j$  levies a cooperative tariff, which yields:

$$V_t^{ir}(\tau^{ic}, \tau^{jc}) = v_i(\rho_{jk} Q_{jk}(\tau^{ic}), \tau_t^{im}) + r_{ik}(Q_{ik}(\tau^{jc}), \tau^{jc}) + \tau_t^{im} \rho_{jk} Q_{jk}(\tau^{ic}).$$

With probability  $\varphi_i^c (1-\varphi_j^c)$  country  $j$  receives a producer price low enough to trigger a punishment for country  $i$ . During punishment country  $i$  must levy a cooperative tariff and their producers face a Nash-tariff. It is the same as if country  $j$  deviated on them.

$$V_t^{ip}(\tau^{ic}, \tau^{jc}) = v_i(Q_{jk}(\tau^{ic}), \tau^{ic}) + r_{ik}(\rho_{ik}Q_{ik}(\tau^c), \tau_t^{im}) + \tau^{ic}Q_{jk}(\tau^{ic}).$$

Finally, with probability  $(1-\varphi_i^c)(1-\varphi_j^c)$  both countries receive a producer price low enough to trigger a retaliatory stage. So with probability  $(1-\varphi_i^c)(1-\varphi_j^c)$  country  $i$  will receive an expected payoff of

$$(1/2)V_t^{ir}(\tau^{ic}, \tau^{jc}) + (1/2)V_t^{ip}(\tau^{ic}, \tau^{jc})$$

If countries are in a cooperative phase in period  $t$ , then the value of abiding by the agreement is:

$$G^{icc} = V^{ic} + \delta[\varphi_i^c \varphi_j^c G^{icc} + \varphi_j^c (1-\varphi_i^c)G^{ir} + \varphi_i^c (1-\varphi_j^c)G^{ip} + (1-\varphi_i^c)(1-\varphi_j^c)(G^{ir} + G^{ip})/2].$$

With probability  $\varphi_i^c \varphi_j^c$  they enter a cooperative phase in the next period, with probability  $\varphi_j^c (1-\varphi_i^c)$  they enter a retaliatory phase, with probability  $\varphi_i^c (1-\varphi_j^c)$  they enter a punishment phase, and with probability  $(1-\varphi_i^c)(1-\varphi_j^c)$  they have an equal chance of entering a retaliatory or a punishment phase.

The retaliation and the punishment phases also afford recursive representations and are given by:

$$G^{ir} = V^{ir} + \delta[\pi(\varphi_i^c G^{icc} + (1-\varphi_i^c)G^{ir}) + (1-\pi)G^{ir}].$$

$$G^{ip} = V^{ip} + \delta[\pi(\varphi_j^c G^{icc} + (1-\varphi_j^c)G^{ip}) + (1-\pi)G^{ip}].$$

Solving these three equations simultaneously, and writing  $\gamma_i = 1 - \delta(1 - \pi\varphi_i^c)$  and  $\gamma_j = 1 - \delta(1 - \pi\varphi_j^c)$ , yields:

$$G^{icc} = \frac{2\gamma_i\gamma_j V^{ic} + \gamma_i(1-\varphi_i^c)(1+\varphi_j^c)\delta V^{ir} + \gamma_j(1-\varphi_j^c)(1+\varphi_i^c)\delta V^{ip}}{2\gamma_i\gamma_j(1-\delta\varphi_i^c\varphi_j^c) - \gamma_i(1-\varphi_i^c)(1+\varphi_j^c)\delta^2\pi\varphi_j^c - \gamma_j(1-\varphi_j^c)(1+\varphi_i^c)\delta^2\pi\varphi_i^c}$$

It is again straightforward to verify that without uncertainty, ( $\varphi_i^c = \varphi_j^c = 1$ ), the expression for  $G^{icc}$  reduces to  $V^{ic}/(1-\delta)$ . In the symmetric misinterpretation case, when  $\varphi_i^c = \varphi_j^c = \varphi$ , we have

$$G^{iccs} = \frac{2(1-\delta(1-\pi\varphi))V^{ic} + (1-\varphi^2)\delta(V^{ir} + V^{ip})}{2(1-\delta)(1-\delta\varphi(\varphi-\pi))}$$

We can write the firms' expected profits as:

$$R^{icc} = \frac{[2\gamma_i\gamma_j + \gamma_i(1-\varphi_i^c)(1+\varphi_j^c)\delta]r^{ic} + \gamma_j(1-\varphi_j^c)(1+\varphi_i^c)\delta r^{ip}}{2\gamma_i\gamma_j(1-\delta\varphi_i^c\varphi_j^c) - \gamma_i(1-\varphi_i^c)(1+\varphi_j^c)\delta^2\pi\varphi_j^c - \gamma_j(1-\varphi_j^c)(1+\varphi_i^c)\delta^2\pi\varphi_i^c}$$

In the symmetric misinterpretation case, when  $\varphi_i^c = \varphi_j^c = \varphi$ , we can write

$$R^{iccs} = \frac{[2(1-\delta(1-\pi\varphi)) + (1-\varphi^2)\delta]r^{ic} + (1-\varphi^2)\delta r^{ip}}{2(1-\delta)(1-\delta\varphi(\varphi-\pi))}$$

Maximizing  $R^{icc}$  with respect to  $Q$  for the competitive firms (taking price as given) yields the competitive quantity chosen in anticipation that countries will abide by the agreement:

$$Q_{ik}^{cc} = \frac{[2\gamma_i\gamma_j + \delta\gamma_i(1-\varphi_i^c)(1+\varphi_j^c)](\theta_{ik} - \tau^{jc})}{4\gamma_i\gamma_j + 2\delta\gamma_i(1-\varphi_i^c)(1+\varphi_j^c) + \rho_{ik}^2\delta\gamma_j(1-\varphi_j^c)(1+\varphi_i^c)}$$

Again we note that if  $\varphi_i^c = \varphi_j^c = 1$  (or  $\delta = 0$  or  $\rho_{ik} = 0$ ), then  $Q_{ik}^{cc} = \frac{\theta_{ik} - \tau^{jc}}{2}$ . Although we have a similar

set of comparative statics as in equation 12, the firms' quantity choices are more sensitive to quality and less sensitive to irreversibility and these differences help drive our results. In the symmetric misinterpretation case, when  $\varphi_i^c = \varphi_j^c = \varphi$ , we have that

$$Q_{ik}^{ccs} = \frac{[2(1-\delta(1-\pi\varphi) + \delta(1-\varphi^2))](\theta_{ik} - \tau^{jc})}{4(1-\delta(1-\pi\varphi) + (2+\rho_{ik}^2)\delta(1-\varphi^2))}$$

To help develop intuition as to how SDS can ameliorate the uncertainty driven quality selection problem it is perhaps most helpful to see what happens when at least one country does not misinterpret their partner's trade barriers. We, therefore, first consider the limiting case when either  $\varphi_i^c = 1$  or  $\varphi_j^c = 1$ .

**Proposition 6:** (i.) *With SDS, if country  $j$  does not misinterpret country  $i$ 's trade policy, then the country  $i$  firms' quantity and quality choices are efficient. Choices under WDS remain inefficient.*

(ii.) *With SDS, if country  $i$  does not misinterpret country  $j$ 's trade policy, then country  $i$ 's firms' quantity and quality choice exhibit the same inefficiencies as in the WDS case.*

The proof of Proposition 6 is in the appendix. Part (i.) of proposition 6 indicates that, with SDS, the inefficient quality choice problem stems from the partner's trade policy misinterpretation. If the partner observed the trade policy with perfect clarity, then with SDS there is no problem. Of course with WDS the problem would remain. Part (ii.) reinforces part (i.) by suggesting that, even when there is SDS, not misinterpreting the trade partner's policy does not help the firm's quality decision. In fact, in this limiting case SDS and WDS are equal. The proposition also suggests that, with SDS, countries have more of an incentive to encourage the clarity with which their trade policy is observed but have no incentive to improve their observational clarity of their partner's policy.

We now consider the symmetric misinterpretation case so that  $\varphi_j^c = \varphi_i^c = \varphi$ . We write  $\gamma^* = (1 - \delta(1 - \pi\varphi))$  and we note that  $\gamma > \gamma^*$ . Similarly, note that  $2\gamma^* > \delta(1 - \varphi^2)$  if  $\varphi(\varphi + 2\pi) > 3 - 2/\delta$ . This assumption is weaker than equation (13) with respect to  $\delta$  and  $\pi$  (it is trivially satisfied if  $\delta \leq 2/3$ ), however, it does place a little more restriction on  $\varphi$ . Given equation (13), it is satisfied for all  $\delta$  if  $\varphi \geq 1/2$ . We show below that with SDS we also have that for all  $\{\theta_{ih}, \theta_{il}, \rho_{il}\}$  there is a positive measure of high-quality irreversibility realizations  $1 - \rho^S(\theta_{ih}, \theta_{il}, \rho_{il})$  such that firms would choose low quality. The important point is that for all  $\{\theta_{ih}, \theta_{il}, \rho_{il}\}$  this measure is strictly smaller with SDS than with WDS.

**Proposition 7:** *The measure of high-quality irreversibility realizations such that firms would choose low quality is strictly lower under SDS than under WDS. Firms are less likely to choose lower quality with SDS than with WDS.*

The proof of Proposition 7 is contained in the appendix. The idea of the proof is illustrated in figure 6. We see there that firm profits are increasing faster in quality with SDS than with WDS. In addition, the negative effect of irreversibility on profits and on quality is less pronounced under SDS than under WDS. We also see that for  $\rho_{ih} > \rho_{il}$ , the distance  $\theta(\rho_{ih}) - \theta(\rho_{il})$  such that  $R^{iccs}(\theta(\rho_{il}), \rho_{il}) = R^{iccs}(\theta(\rho_{ih}), \rho_{ih})$  is smaller with SDS than with WDS. Hence, it must be the case that  $\rho^S(\theta_{ih}, \theta_{il}, \rho_{il}) > \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$  so that firms are less likely to choose low quality with SDS than with WDS.

## Conclusion

In this paper we consider the joint choice of quality and export promotion costs when trade relationships are subject to temporary disputes. When transparency is low or macroeconomic instability is high, disputes arrive more frequently and, therefore, firms may inefficiently choose lower levels of quality and export promotion. These, in turn, build shallower trading relationships with less trade volumes and higher tariffs, and generate greater trade reductions during the more common trade disputes. Several institutional features of the WTO, such as improved transparency, dispute investigation, and the provision to recommend asymmetric continuation payoffs can ameliorate these inefficient quality choice

outcomes. Hence, lower quality output and lower quality trading relationships may be more endemic to countries that depend on preferential trading areas or unilateral preferences as opposed to the WTO.

An implication of our model is that the greater transparency afforded by the WTO's DSM should generate fewer trade disputes. In contrast to this prediction we note that there have been more annual disputes in the WTO than in the GATT. This initial data observation, however, does not tell the entire story. First, many disputes are settled early before the full panel process, or before any trade restrictions are levied. Out of 369 disputes in the WTO (as of January, 2008) only 136 have reached the full panel process. The remaining 233 are either in negotiation or were settled without sanctions and, therefore, would not qualify as the trade distorting disputes that we consider in this paper. Furthermore, as Grinols and Perrelli (2006) show, although the annual number of cases in the WTO is larger than in the GATT, they have become shorter. In particular, their length has been reduced for the first and final third of cases. The shortening of the first third suggests that the increased transparency in the WTO's DSM is helping more cases to be settled before they become a trade distorting dispute. The time reduction of the final third suggests that the DSM is also helping prevent longer-lasting more harmful disputes.

The increase in the number of cases may also indicate a transfer of other types of disputes to the WTO. For example, 19 out of 102 (19 percent) of the US Trade representative special 301 cases before December 1994 were also contested in the GATT, but 12 out of 22 (55 percent) between 1995 and 1999 were also decided in the WTO (Grinols and Perrelli, 2006). In addition, although antidumping claims are not adjudicated by the WTO's DSM, several WTO cases contest the abuse of antidumping actions. That is, instead of responding to antidumping actions with a retaliatory antidumping claim,<sup>26</sup> countries increasingly are turning to the WTO's DSM to prevent dispute escalation. Hence, neither of these types of cases should be considered as an increase in the number of disputes but rather a transfer of dispute resolution to a more efficient adjudicator. An important implication of this paper is that the transfer of these sorts of disputes to the WTOs DSM is welfare enhancing. Finally, the total number of cases in the

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<sup>26</sup> For more on the negative club effects of antidumping claims see Blonigen and Bown (2003), Blonigen and Prusa (2003), Prusa (2001), and Prusa and Skeath (2004).

WTO (averaging less than twenty per year) is a relatively small number of the total number of trade disputes (or even antidumping cases) in any year. Although beyond the scope of this paper an important direction for further research is how to transfer more of these harmful disputes to the WTO's DSM.<sup>27</sup>

An additional implication of our model is that trade disputes would increase during recessions. Although the popular press reported an increase in trade barriers as a result of the recession (Landler, 2009) these barriers are not the same as the number of disputes. On the one hand, there was an increase in the number of antidumping measures during this last recession (the number of antidumping claims steadily declined from a high of 366 in 2001 to 163 in 2007, but this trend reversed itself with 208 in 2008 and 209 in 2009). On the other hand, the number of WTO cases shows no clear trend (the number of cases oscillated between 20 and 12 from 2004 to 2007 and between 19 and 14 in the recession of 2008 and 2009). An important topic for further research is understanding how the business cycle affects the frequency of the several differing types of trade disputes discussed in this paper.<sup>28</sup>

Underlying our model is the empirical regularity of trade disputes. Although the WTO's DSM can ameliorate some of their harmful effects it is not immediately obvious why disputes should exist in the first place. As Bagwell and Staiger (2005) show, if working escape clauses are available, then macroeconomic fluctuations should not generate trade disputes. Hence, an important topic for further research is to what extent the use of safeguards (such as GATT article XIX or XXVIII) may also generate negative quality choice and integration effects and whether safeguards can be designed to mitigate all

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<sup>27</sup> The U.S. and Mexico have both brought NAFTA cases to the WTO when the good is covered by both agreements. No cross retaliation in sectors that are covered only in NAFTA and not the WTO have been asked for or approved by the WTO. The WTO's dispute settlement understanding (DSU) article 22, paragraph 3, allows for cross retaliation in sectors and even agreements other than the one where the dispute originated, however, it specifically subordinates more distant cross-retaliations to those that are in the same sector or at least the same agreement. Paragraph 5 of article 22 prohibits cross retaliation if the covered agreement does not allow for suspension of concessions. Other than these guidelines in paragraphs 3 and 5, the DSU provides no hard and fast rule on cross retaliation in PTAs. There has not yet been cross-retaliation in goods only covered in a PTA and not the WTO. There may at present be a separate implicit arrangement to not cross retaliate in these other agreements – the analysis of which may present an interesting direction for further research. The relationship between dispute settlement in the WTO and PTAs is well beyond the scope of this paper, however, it is an important area for further research.

<sup>28</sup> Bagwell and Staiger (2003) provide an analysis of protection over the business cycle and they cite a large literature that shows that protection is countercyclical. Their paper is concerned with protection and not disputes. An important additional question is how the differing types of disputes respond over the business cycle.



negative effects. Still, as shown by Bown (2004) countries may prefer to forego the use of safeguards (and their required compensation) and would instead choose to violate the rules of the GATT/WTO and face the possibility of sanctions in a subsequent trade dispute. Furthermore, the majority of trade disputes and bouts of protectionism exist outside the direct provision of the WTO's DSM and as suggested in this paper many depend on the ability to selectively misinterpret a trade partner's policies. As Park (Forthcoming) shows, the WTO's institutional framework can help mitigate certain negative effects of private observation of a trade partner's policies. It is, therefore, important for trade policy researchers and practitioners to better understand how and why countries could be persuaded to forego the benefits of selective misinterpretation and to adhere more fully to the WTO's institutional framework.

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## References

- Alessandria, George, Joseph Kaboski, and Virgiliu Midrigan, 2008. "Inventories, Lumpy Trade, and Large Devaluations," NBER Working Paper 13790. February, 2008.
- Abreu, Dilip., David Pearce, and Ennio Stacchetti, 1990. "Toward a Theory of Discounted Repeated Games with Imperfect Monitoring," *Econometrica*, 58:5, pp. 1041-1063.
- Álvarez, Roberto and Ricardo A. López, 2005. "Exporting and Performance: Evidence from Chilean Plants," *Canadian Journal of Economics*, 38:4, pp. 1384-1400.
- Bagwell, Kyle and Robert W. Staiger, 1990. "A Theory of Managed Trade," *American Economic Review*, 80:4, pp. 779-795 .
- Bagwell, Kyle and Robert W. Staiger, 1999. "An Economic Theory of GATT," *American Economic Review*, 89:1, pp. 215-248.
- Bagwell, Kyle and Robert W. Staiger, 2002. *The Economics of the World Trading System*. Cambridge, MA: MIT Press.
- Bagwell, Kyle and Staiger, Robert W., 2003. "Protection and the Business Cycle," *Advances in Economic Analysis & Policy*, 3:1, Article 3.
- Bagwell, Kyle and Robert W. Staiger, 2005. "Enforcement, Private Political Pressure and the GATT/WTO Escape Clause," *The Journal of Legal Studies*, 34:2, pp. 471-513.
- Baldwin, Robert and Paul Krugman, 1989. "Persistent Trade Effects of Large Exchange Rate Shocks," *Quarterly Journal of Economics*, 104:4, pp. 635-654.
- Bello, Judith Hippler, 1996. "The WTO Dispute Settlement Understanding: Less is More," *American Journal of International Law*, 90, pp. 416-18.
- Bernheim, B. Douglas, and Whinston, Michael D, 1990. "Multimarket Contact and Collusive Behavior," *RAND Journal of Economics*, 21:1, pp. 1-26.
- Ben-David, Dan, 2000. "Trade, Growth And Disparity Among Nations." *Trade, Income Disparity And Poverty*. World Trade Organization Special Study 5, pp. 11-42. Geneva: WTO Publications.
- Blonigen, Bruce A. and Chad P. Bown, 2003. "Antidumping and Retaliation Threats," *Journal of International Economics*, 60:2, pp. 249-273.
- Blonigen, Bruce A. and Thomas J. Prusa, 2003. "Antidumping," in E. Kwan Choi and James Harrigan (eds.) *Handbook of International Trade*. Oxford, UK: Blackwell Publishers.
- Bown, Chad P., 2004. "Trade Disputes and the Implementation of Protection under the GATT: An Empirical Assessment," *Journal of International Economics*, 62:2, pp. 263-294.
- Bown, Chad P., 2007. "The WTO and Antidumping in Developing Countries," *Economics and Politics*, 20:2, pp. 255-288.
- Bown, Chad P. and Meredith A. Crowley, 2007. "Trade Deflection and Trade Depression," *Journal of International Economics*, 72:1, pp. 176-201.

Bown, Chad P. and Meredith A. Crowley, 2010. "China's Export Growth and the China Safeguard: Threats to the World Trading System?" *Canadian Journal of Economics*, 43:4, pp. 1353-1388.

Brander, James A. and Paul Krugman, 1983. "A 'Reciprocal Dumping' Model of International Trade," *Journal of International Economics*, 15, pp. 313-321.

Brooks, Eileen. 2006. "Why Don't Firms Export More? Product Quality and Colombian Plants," *Journal of Development Economics*, 80:1 pp. 160-178.

Chen, Maggie X. and Aaditya Mattoo, 2006. "Regionalism in Standards: Good or Bad for Trade?" World Bank working paper #3458

Chisik, Richard, 2003. "Gradualism in Free Trade Agreements: A Theoretical Justification," *Journal of International Economics*, 59:2, pp. 367-397.

Chisik, Richard and Ronald B. Davies, 2004. "Gradualism in Tax Treaties with Irreversible Foreign Direct Investment," *International Economic Review*, 45:1, pp. 113-139.

Clendenning, Alan, 2004. "Mercosur Meets Amid Criticism," *Miami Herald*, December 15, 2004, section C, page 2.

Das, Sanghamitra, Mark Roberts, and James Tybout, 2007. "Market Entry Costs, Producer Heterogeneity and Export Dynamics," *Econometrica*, 75:3, pp. 837-873.

Dixit, Avinash, 1987. "Strategic Aspects of Trade Policy." In Truman F. Bewley, ed., *Advances in Economic Theory: Fifth World Congress*. Cambridge: Cambridge University Press, 1987, pp. 329-62.

Dixit, Avinash, 1989. "Entry and Exit Decisions under Uncertainty," *Journal of Political Economy*, 97:3, pp. 620-638.

Eaton, Jonathan, Samuel Kortum, and Francis Kramarz, 2006. "An Anatomy of International Trade: Evidence from French Firms." University of Minnesota, mimeograph.

Fudenberg, Drew, David Levine and Eric Maskin, 1994. "The Folk Theorem with Imperfect Public Monitoring," *Econometrica*, 62:5, pp. 997-1039.

Fox, James W., 2004. "An Evaluation of Trade Capacity Building Programs Regional Trade Agreements: A Tool for Development?," USAID PPC evaluation working paper # 15. PN- ACT-170.

Green, Edward and Robert Porter, 1984. "Noncooperative Collusion under Imperfect Price Information," *Econometrica*, 52:1, pp. 87-100.

Grossman, Gene and Elhanan Helpman, 1991. *Innovation and Growth in the World Economy*. Cambridge, MA: MIT Press.

Hallak, Juan Carlos, 2006. "Product Quality and the Direction of Trade," *Journal of International Economics*, 68:1, pp. 238-265.

Hausman, Ricardo, Jason Hwang and Dani Rodrik, 2007. "What You Export Matters," *Journal of Economic Growth*, 12, pp.1-25.

Hoekman, Bernard M. and Michel M. Kostecki. 2001. *The Political Economy of the World Trading System*. 2nd ed. New York: Oxford University Press.

Grinols, Earl L. and Roberto Perrelli, 2006. "The WTO Impact on International Trade Disputes: An Event History Analysis," *The Review of Economics and Statistics*, 88:4, pp. 613-624.

Hungerford, Thomas, 1991. "GATT: A Cooperative Equilibrium in a Noncooperative Trading Regime?" *Journal of International Economics*, 31:3-4, pp. 357- 369.

Johnson, Harry G., 1953. "Optimum Tariffs and Retaliation." *Review of Economic Studies*, 1953-1954, 21:2, pp.142-153

Klimenko, Mikhail, Garey Ramey and Joel Watson, 2008. "Recurrent Trade Agreements and the Value of External Enforcement," *Journal of International Economics* 74:2, pp. 475–499.

Kovenock, Dan and Marie Thursby, 1992. "GATT, Dispute Settlement and Cooperation," *Economics and Politics*, 4:2, pp. 151-170.

Landler, Mark, 2009. "Trade Barriers Rise as the Recession's Grip Tightens," *The New York Times*, March 23, 2009, Section A, page 1.

Lapan, Harvey, 1988. "The Optimal Tariff, Production Lags, and Time Consistency," *American Economic Review*, 78:3, pp. 395-401.

Lee, Gea M., 2007. "Trade Agreements with Domestic Policies As Disguised Protection," *Journal of International Economics*, 71:1, pp. 241-59.

Linder, Staffan Burenstam, 1961. *An Essay on Trade and Transformation*, New York: Wiley & Sons.

Lipsey, R.G. and Kelvin Lancaster, 1956 – 1957. "The General Theory of Second Best," *The Review of Economic Studies*, 24:1, pp. 11-32

Martin, Alberto and Wouter Vergote, 2008. "On the Role of Retaliation in Trade Agreements," *Journal of International Economics*, 76:1, pp. 61-77.

McLaren, John, 1997. "Size, Sunk Costs, and Judge Bowker's Objection to Free Trade," *American Economic Review*, 87:3, pp. 400-420.

Mill, John Stuart, 1844. *Essays on Some Unsettled Questions of Political Economy*. London: John W. Parker.

Park, Jee-Hyeong, Forthcoming. "Enforcing International Trade Agreements with Imperfect Private Monitoring," *The Review of Economic Studies*.

Prusa, Thomas J., 1992. "Why Are So Many Antidumping Petitions Withdrawn?" *Journal of International Economics* 33:1-2, pp. 1-20.

Prusa, Thomas J., 1997. "The Trade Effects of U.S. Antidumping Actions." in Robert C. Feenstra, (ed.) *The Effects of U.S. Trade Protection and Promotion Policies*, University of Chicago Press.

Prusa, Thomas J., 2001. "On the Spread and Impact of Antidumping," *Canadian Journal of Economics* 34:3, pp. 591-611.

Prusa, Thomas J. and Susan Skeath, 2004. "Modern Commercial Policy: Managed Trade or Retaliation?" in E. Kwan Choi and James Hartigan (eds.), *Handbook of International Trade* (Vol. II). Malden, MA: Blackwell Publishing.

Rauch, James E., 2007. "Development Through Synergistic Reform," NBER Working Paper 13170, June 2007

Riezman, Raymond, 1991. "Dynamic Tariffs with Asymmetric Information." *Journal of International Economics*, 30:3-4, pp. 267-83.

Roberts, Mark J. and James R Tybout, 1997. "The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs," *American Economic Review*, 87:4, pp. 545-64.

Smith, James McCall, 2000. "The Politics of Dispute Settlement Design: Explaining Legalism in Regional Trade Pacts," *International Organization* 54:1, pp. 137-80.

Vernon, Raymond, 1966. "International Investment and International Trade in the Product Cycle," *Quarterly Journal of Economics*, 80, pp. 190-207.

Yeats, Alexander, 1998. "Does Mercosur's Trade Performance Raise Concerns about the Effects of Regional Trade Arrangements?" *The World Bank Economic Review* 12:1, pp. 1-28.

## Appendix: Proofs.

**Proof of Proposition 4:** (i.) We start by writing out the expressions for the payoffs.

$$\Psi_t^i = (\tau_t^{id} (Q_{jk}^c) - \tau^{ic}) \cdot Q_{jk}^c$$

$$\Omega_t^i = \Delta[(1 - \rho_{jk}^2)(Q_{jk}^c)^2 / 2 + (\tau^{ic} - \tau_t^{im}(\rho_{jk} Q_{jk}^c) \rho_{jk}) Q_{jk}^c + P_{it}^{ic} Q_{ik}^c - (Q_{ik}^c)^2 / 2 + (\rho_{ik} \cdot Q_{ik}^c)^2 / 2] =$$

$$\Delta[(1 - \rho_{jk}^2)(Q_{jk}^c)^2 / 2 + (\tau^{ic} - \rho_{jk} \theta_{jk} + \rho_{jk}^2 Q_{jk}^c) Q_{jk}^c + (\theta_{ik} - \tau^{jc} - Q_{ik}^c) Q_{ik}^c - (Q_{ik}^c)^2 / 2 + (\rho_{ik} \cdot Q_{ik}^c)^2 / 2]$$

We now consider the shape of these two functions with respect to the cooperative tariff,  $\tau^{ic}$ . With respect to the first, note that  $\tau_t^{id} \geq \tau^{ic}$ ,  $0 > \frac{\partial Q_{jk}^c}{\partial \tau^{ic}} > -1/2$ , and  $\frac{\partial \tau_t^{id}}{\partial Q_{jk}^c} > -2$  by assumption, therefore,

$$\frac{\partial \Psi_t^i}{\partial \tau^{ic}} = (\tau_t^{id} (Q_{jk}^c) - \tau^{ic}) \cdot \frac{\partial Q_{jk}^c}{\partial \tau^{ic}} + (\frac{\partial \tau_t^{id}}{\partial Q_{jk}^c} \frac{\partial Q_{jk}^c}{\partial \tau^{ic}} - 1) Q_{jk}^c < 0,$$

therefore,  $\Psi_t^i$  is strictly decreasing  $\tau^{ic}$ . Also note that when  $\tau^{ic} = 0$ ,  $\Psi_t^i > 0$ . Furthermore, when  $\tau^{ic} \rightarrow \tau_1^{im}$ , we have that  $Q_{jk}^c \rightarrow 0$  and also that  $\tau_t^{id} \rightarrow \tau_1^{im}$ , therefore,  $\tau_t^{id} \rightarrow \tau^{ic}$ . Hence,

$$\lim_{\tau^{ic} \rightarrow \tau_1^{im}} \frac{\partial \Psi_t^i}{\partial \tau^{ic}} \rightarrow 0 = \Psi_t^i(\tau^{ic} = \tau_1^{im}).$$

With respect to the discounted future cost of deviating, we have:

$$\frac{\partial \Omega_t^i}{\partial \tau^{ic}} = \Delta \left[ ([1 + \rho_{jk}^2] Q_{jk}^c + [\tau^{ic} - \rho_{jk} \theta_{jk}]) \frac{\partial Q_{jk}^c}{\partial \tau^{ic}} + Q_{jk}^c \right]$$

$$\frac{\partial^2 \Omega_t^i}{\partial \tau^{ic2}} = \Delta \left[ \left( 2 + [1 + \rho_{jk}^2] \frac{\partial Q_{jk}^c}{\partial \tau^{ic}} \right) \frac{\partial Q_{jk}^c}{\partial \tau^{ic}} \right] < 0.$$

The strict concavity of  $\Omega_t^i$  arises because  $\frac{\partial^2 Q_{jk}^c}{\partial \tau^{ic2}} = 0$  and because  $\frac{\partial Q_{jk}^c}{\partial \tau^{ic}} \in (-1/2, 0)$  so that

$$2 + [1 + \rho_{jk}^2] \frac{\partial Q_{jk}^c}{\partial \tau^{ic}} > 0.$$

Furthermore, when  $\tau^{ic} = \tau_1^{im}$ ,  $Q_{jk}^c = 0$  so that  $\tau_1^{im} = \theta_j$ . Hence,

$$\lim_{\tau^{ic} \rightarrow \tau_1^{im}} \frac{\partial \Omega_t^i}{\partial \tau^{ic}} = \Delta \left[ \theta_{jk} (1 - \rho_{jk}) \frac{\partial Q_{jk}^c}{\partial \tau^{ic}} \right] < 0 \text{ as long as } \rho < 1. \text{ Hence, } \lim_{\tau^{ic} \rightarrow \tau_1^{im}} \left( \frac{\partial \Omega_t^i}{\partial \tau^{ic}} - \frac{\partial \Psi_t^i}{\partial \tau^{ic}} \right) < 0. \text{ Furthermore,}$$

because  $Q_{jk}^c = 0$  when  $\tau^{ic} = \tau_1^{im}$ , we have that  $\Omega_t^i = \Psi_t^i = 0$  when  $\tau^{ic} = \tau_1^{im}$ . We have not only

established that  $\Omega_t^i$  is strictly concave and that  $\Psi_t^i$  is strictly decreasing in  $\tau^{ic}$  but also that  $\Omega_t^i$

approaches  $\Psi_t^i$  from above when  $\tau^{ic}$  approaches  $\tau_1^{im}$  from below. Hence, there is a  $\tau^{ic} < \tau_1^{im}$  that is

self-enforcing and Pareto improving and the agreement chooses the lowest  $\tau^{ic}$  in this range.  $\square$

**Proof of Proposition 5:**  $\frac{\partial \Psi_t^i}{\partial \theta_{ik}} = 0 = \frac{\partial \Psi_t^i}{\partial \rho_{ik}}$ .

$$\begin{aligned} \frac{\partial \Omega_t^i}{\partial \theta_{ik}} &= \Delta \left[ Q_{ik}^c + (\theta_{ik} - \tau^{jc} - 3Q_{ik}^c + \rho_{ik}^2 Q_{ik}) \frac{\partial Q_{jk}^c}{\partial \theta_{ik}} \right] \geq \Delta \left[ Q_{ik}^c + (\theta_{ik} - \tau^{jc} - 3Q_{ik}^c) \frac{\partial Q_{jk}^c}{\partial \theta_{ik}} \right] \geq \\ &\Delta \left[ Q_{ik}^c - Q_{ik}^c \frac{\partial Q_{jk}^c}{\partial \theta_{ik}} \right] > \Delta [Q_{ik}^c / 2] > 0 \\ \frac{\partial \Omega_t^i}{\partial \rho_{ik}} &= \Delta \left[ 2\rho_{ik} Q_{ik}^c - 3Q_{ik}^c \frac{\partial Q_{jk}^c}{\partial \rho_{ik}} + (\theta_{ik} - \tau^{jc} + 2\rho_{ik}^2 Q_{ik}) \frac{\partial Q_{jk}^c}{\partial \rho_{ik}} \right] = \\ &\Delta \left[ (2\rho_{ik}^2 Q_{ik} - 3Q_{ik}^c) \frac{\partial Q_{jk}^c}{\partial \rho_{ik}} + 2\rho_{ik} Q_{ik}^2 + (\theta_{ik} - \tau^{jc}) \frac{\partial Q_{jk}^c}{\partial \rho_{ik}} \right] > 0. \end{aligned}$$

because  $(2\rho_{ik}^2 Q_{ik} - 3Q_{ik}^c) \frac{\partial Q_{jk}^c}{\partial \rho_{ik}} > 0$  and  $2\rho_{ik} Q_{ik}^2 + (\theta_{ik} - \tau^{jc}) \frac{\partial Q_{jk}^c}{\partial \rho_{ik}} > 0$  if  $\pi + \phi > 2 - 1/\delta$ , which is given

by equation 13. Finally, note that  $\frac{d\Omega_t^i}{d\theta_{ik}} = \frac{\partial \Omega_t^i}{\partial \theta_{ik}} + \frac{\partial \Omega_t^i}{\partial \rho_{ik}} \frac{d\rho_{ik}}{d\theta_{ik}}$  so the effect is greater if  $\rho'(\theta_{ik})$  is larger.  $\square$

**Proof of Proposition 6:** (i.) When  $\varphi_j^c = 1$ , then  $Q_{ik}^{cc} = \frac{[2\gamma_i \gamma_j + 2\delta\gamma_i(1 - \varphi_i^c)](\theta_{ik} - \tau^{jc})}{4\gamma_i \gamma_j + 4\delta\gamma_i(1 - \varphi_i^c)} = \frac{(\theta_{ik} - \tau^{jc})}{2}$

Similarly,  $R^{icc} = \frac{[2\gamma_i \gamma_j + 2\delta\gamma_i(1 - \varphi_i^c)]r^{ic}}{2\gamma_i \gamma_j(1 - \delta\varphi_i^c) - \gamma_i 2(1 - \varphi_i^c)\delta^2\pi} = \frac{[\gamma_j + \delta(1 - \varphi_i^c)]}{\gamma_j(1 - \delta\varphi_i^c) - (1 - \varphi_i^c)\delta^2\pi} r^{ic}$  where the constant has no effect on the firm's optimization. Hence, the firm's optimal quantity  $\frac{(\theta_{ik} - \tau^{jc})}{2}$  is increasing in  $\theta_{ik}$  and

is not a function of irreversibility or uncertainty. The WDS case is as given in proposition 2 with  $\varphi_i^c = \phi$ .

(ii.) When  $\varphi_i^c = 1$ , then using that  $\gamma_i = \gamma$  and that  $\varphi_j^c = \phi$  we have

$$Q_{ik}^{cc} = \frac{[2\gamma_i \gamma_j](\theta_{ik} - \tau^{jc})}{4\gamma_i \gamma_j + 2\rho_{ik}^2 \delta\gamma_j(1 - \varphi_j^c)} = \frac{\gamma_i(\theta_{ik} - \tau^{jc})}{2\gamma_i + \rho_{ik}^2 \delta(1 - \varphi_j^c)} = \frac{\gamma(\theta_{ik} - \tau^{jc})}{2\gamma + \delta(1 - \phi)\rho_{ik}^2} = \frac{\gamma(\theta_{ik} - \tau^{jc})}{2\gamma + \delta(1 - \phi)\rho_{ik}^2} = Q_{ik}^c$$

So that output is the same as the WDS case considered in proposition 2. Similarly,

$$R^{icc} = \frac{\gamma r^{ic} + (1 - \varphi_j^c)\delta r^{ip}}{1 - \delta(1 - \pi + \varphi_j^c) + \delta^2(\varphi_j^c - \pi)} = R^{ic} \text{ so that the quality and irreversibility choice are the same as the}$$

WDS case.  $\square$

**Proposition 7:** The key to the proof is showing that  $\frac{\partial R_k^{iccs}}{\partial \theta_{ik}} > \frac{\partial R_k^{ic}}{\partial \theta_{ik}}$ , that  $\left| \frac{\partial^2 R_k^{iccs}}{\partial \rho_{ik} \partial \theta_{ik}} \right| < \left| \frac{\partial^2 R_k^{ic}}{\partial \rho_{ik} \partial \theta_{ik}} \right|$  and that

$\left| \frac{\partial R_k^{iccs}}{\partial \rho_{ik}} \right| < \left| \frac{\partial R_k^{ic}}{\partial \rho_{ik}} \right|$ . Proceeding as in Proposition 2, and using the envelope result on the optimal choice of

$Q_{ik}^{ccs}$  we have that

$$\frac{\partial R_k^{iccs}}{\partial \theta_{ik}} = \frac{[2\gamma^* + \delta(1 - \varphi^2)]^2 [2\gamma^* + (1 + \rho_{ik}^2)\delta(1 - \varphi^2)]^2 (\theta_{ik} - \tau^{jc})}{[4\gamma^* + (2 + \rho_{ik}^2)\delta(1 - \varphi^2)]^2 2(1 - \delta)(1 - \delta\varphi(\varphi - \pi))} > 0.$$

$$\begin{aligned} \frac{\partial R_k^{iccs}}{\partial \rho_{ik}} &= \frac{(2\gamma^* + \delta(1 - \varphi^2))(-Q_{ik}^{ccs} \frac{\partial Q_{ik}^{ccs}}{\partial \rho_{ik}}) - \delta(1 - \varphi^2)\rho_{ik}(Q_{ik}^{ccs})^2}{2(1 - \delta)(1 - \delta\varphi(\varphi - \pi))} = \\ &= \frac{-[2\gamma^* + \delta(1 - \varphi^2)]^2 \rho_{ik}^3 \delta^2 (1 - \varphi^2)^2 (\theta_{ik} - \tau^{jc})^2}{[4\gamma^* + (2 + \rho_{ik}^2)\delta(1 - \varphi^2)]^2 2(1 - \delta)(1 - \delta\varphi(\varphi - \pi))} < 0. \\ \frac{\partial^2 R_k^{iccs}}{\partial \rho_{ik} \partial \theta_{ik}} &= \frac{-[2\gamma^* + \delta(1 - \varphi^2)]^2 \rho_{ik}^3 \delta^2 (1 - \varphi^2)^2 (\theta_{ik} - \tau^{jc})}{[4\gamma^* + (2 + \rho_{ik}^2)\delta(1 - \varphi^2)]^2 (1 - \delta)(1 - \delta\varphi(\varphi - \pi))} < 0. \end{aligned}$$

We will also define for the future the term  $v = (1 - \phi)\delta$  so that  $v_i = v\rho_{ik}^2$ .

That  $\left| \frac{\partial^2 R_k^{iccs}}{\partial \rho_{ik} \partial \theta_{ik}} \right| < \left| \frac{\partial^2 R_k^{ic}}{\partial \rho_{ik} \partial \theta_{ik}} \right|$  and  $\left| \frac{\partial R_k^{iccs}}{\partial \rho_{ik}} \right| < \left| \frac{\partial R_k^{ic}}{\partial \rho_{ik}} \right|$  reduces after some algebra to showing that

$$\begin{aligned} &128\gamma^2\gamma^{*2} + (192 + 96\rho_{ik}^2)\gamma^2\gamma^{*2}v + (96 + 96\rho_{ik}^2 + 16\rho_{ik}^3 + 8\rho_{ik}^4)\gamma^2\gamma^*v^2 + \\ &(16 + 24\rho_{ik}^2 + 12\rho_{ik}^4 + 2\rho_{ik}^6)\gamma^2v^3 > \\ &32\gamma^3\gamma^{*2} + 32\gamma^3\gamma^*v + 8\gamma^3v^2 + 2\rho_{ik}^4\gamma v^3 + 24\rho_{ik}^4\gamma\gamma^{*2}v^2 + 24\rho_{ik}^4\gamma\gamma^*v^3 + 48\rho_{ik}^2\gamma^2\gamma^{*2}v + 48\rho_{ik}^2\gamma^2\gamma^*v^2 + \\ &12\rho_{ik}^2\gamma^2v^3 + 4\rho_{ik}^4\gamma v^4 + 4\rho_{ik}^6\gamma^{*2}v^3 + 4\rho_{ik}^6\gamma^*v^4 + \rho_{ik}^6v^5. \end{aligned}$$

The above inequality holds because  $1 > \gamma > \gamma^* > 0$ ,  $1 > \gamma > v > 0$ , and  $2\gamma^* > v$ .

$$\text{When } \rho_{ik} = 0, \frac{\partial R_k^{iccs}}{\partial \theta_{ik}} = \frac{[2\gamma^* + \delta(1 - \varphi^2)](\theta_{ik} - \tau^{jc})}{8(1 - \delta)(1 - \delta\varphi(\varphi - \pi))} > \frac{\partial R_k^{ic}}{\partial \theta_{ik}} = \frac{\gamma(\theta_{ik} - \tau^{jc})}{4(1 - \delta)(1 - \delta(\varphi^2 - \pi))} \text{ if}$$

$\delta(1 - \varphi^2) > \delta^2[(1 - \varphi^2)(\varphi^2 + \pi - 2\varphi\pi)]$  which is true because  $(\varphi^2 + \pi - 2\varphi\pi) < 1$  for all values of  $\pi$  and  $\varphi$   $< 1$ . Now using that  $\left| \frac{\partial^2 R_k^{iccs}}{\partial \rho_{ik} \partial \theta_{ik}} \right| < \left| \frac{\partial^2 R_k^{ic}}{\partial \rho_{ik} \partial \theta_{ik}} \right|$  we have that  $\frac{\partial R_k^{iccs}}{\partial \theta_{ik}} > \frac{\partial R_k^{ic}}{\partial \theta_{ik}}$  for all values of  $\rho_{ik}$ .

Proceeding as in Proposition 2, we see that for any realization of  $\{\theta_{ih}, \theta_{il}, \rho_{il}\}$  there is a  $\rho^S(\theta_{ih}, \theta_{il}, \rho_{il}) < 1$  such that for all  $\rho_{ih} > \rho^S(\theta_{ih}, \theta_{il}, \rho_{il})$  firms will choose low quality. Because  $\frac{\partial R_k^{iccs}}{\partial \theta_{ik}} > \frac{\partial R_k^{ic}}{\partial \theta_{ik}}$ ,

$$\left| \frac{\partial^2 R_k^{iccs}}{\partial \rho_{ik} \partial \theta_{ik}} \right| < \left| \frac{\partial^2 R_k^{ic}}{\partial \rho_{ik} \partial \theta_{ik}} \right|, \text{ and } \left| \frac{\partial R_k^{iccs}}{\partial \rho_{ik}} \right| < \left| \frac{\partial R_k^{ic}}{\partial \rho_{ik}} \right| \text{ it is straightforward to verify that, under SDS, for any } \rho_{ih} > \rho_{il}$$

such that  $R^{iccs}(\theta_{ik}, \rho_{il}) > R^{iccs}(\theta_{ih}, \rho_{ih})$  for all  $\theta_{ik} \in [\theta(\rho_{il}), \theta(\rho_{ih})]$ , the distance  $\theta(\rho_{ih}) - \theta(\rho_{il})$  is smaller.

Hence for any  $\{\theta_{ih}, \theta_{il}, \rho_{il}\}$ , under SDS the corresponding  $\rho^S(\theta_{ih}, \theta_{il}, \rho_{il}) > \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$  so that the measure of high-quality irreversibility realizations  $1 - \rho^S(\theta_{ih}, \theta_{il}, \rho_{il})$  that generate inefficient low-quality choices is lower under SDS than under WDS.  $\square$

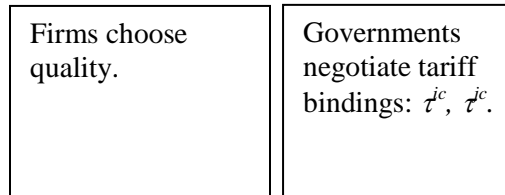


**Table 1: Legal Aspects of PTAs**

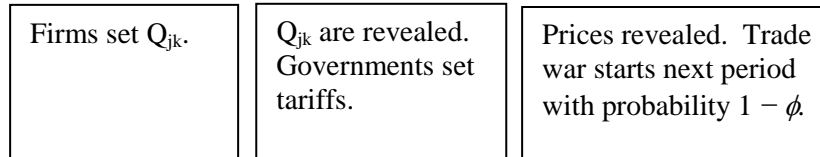
PACT		REVIEWER	RULING	REMEDY
ANZCERTA	(Australia-New Zealand)	None	—	—
BALTIC FTA	(Estonia, Latvia, Lithuania)	None	—	—
CEEC Pacts (5)	(Central and East European Countries)	None	—	—
CEFTA	(Central European Free Trade Agreement)	None	—	—
EEA European Economic Area		None	—	—
1992 EFTA pacts (6)	(Central Europe and Turkey)	None	—	—
Mano River Union	(Liberia, Sierra Leona, Guinea)	None	—	—
SACU	(Southern African Customs Union)	None	—	—
UDEAC	(Central African Customs and Economic Union)	None	—	—
AFTA	(ASEAN Free Trade Area)	Ad Hoc	Not Binding	Comp & Sanc
CARICOM	(Caribbean)	Ad Hoc	Not Binding	Sanctions
EFTA 1960		Ad Hoc	Not Binding	Sanctions
GCC	(Gulf Cooperation Council)	Ad Hoc	Not Binding	NONE
U.S.-Israel Pact		Ad Hoc	Not Binding	Sanctions
(9) Chile & Mexico Pacts		Ad Hoc	Binding	Sanctions
EC associations (12)		Ad Hoc	Binding	NONE
EC-Israel Pact		Ad Hoc	Binding	NONE
EFTA Agreements	(Baltics, Bulgaria, Israel, Slovenia)	Ad Hoc	Binding	NONE
MERCOSUR		Ad Hoc	Binding	Sanctions
NAFTA		Ad Hoc	Some Binding	Direct, Fines, Sanctions
OECS	(Organization of East Caribbean States)	Ad Hoc	Binding	NONE
CEAO	(West African Economic Community)	Tribunal	Binding	NONE
CIS	(Commonwealth of Independent States)	Tribunal	Binding	NONE
EAC	(East African Community)	Tribunal	Binding	NONE
ECOWAS	(Economic Community of West African States)	Tribunal	Binding	Sanctions
Andean Pact		Tribunal	Binding	Direct & Sanctions
CACM	(Central American Common Market)	Tribunal	Binding	Direct
COMESA	(Common Market for Eastern and Southern Africa)	Tribunal	Binding	Sanctions
EC		Tribunal	Binding	Direct
EFTA 1992		Tribunal	Binding	Direct

**Figure 1: Timing**

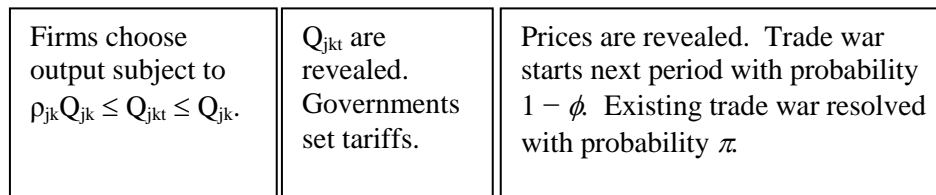
**Timing in Initial Period**



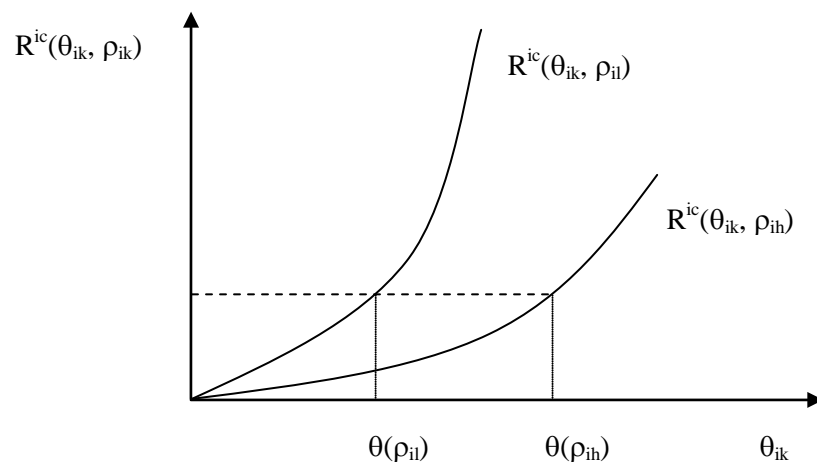
**Timing in Period 1**



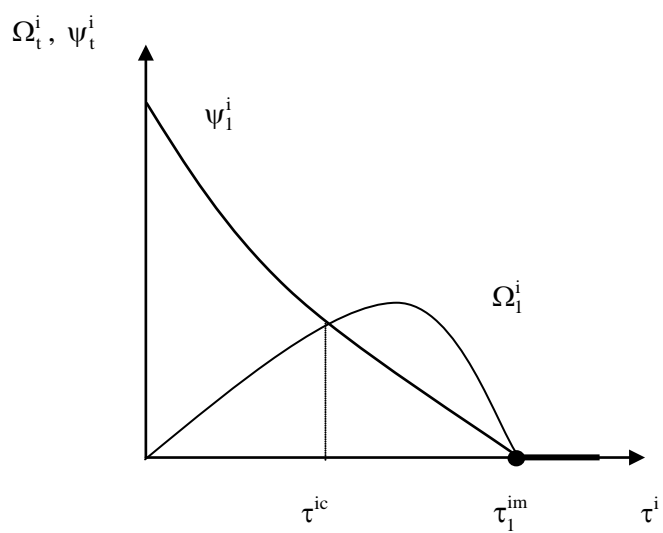
**Timing in Period  $t > 1$**



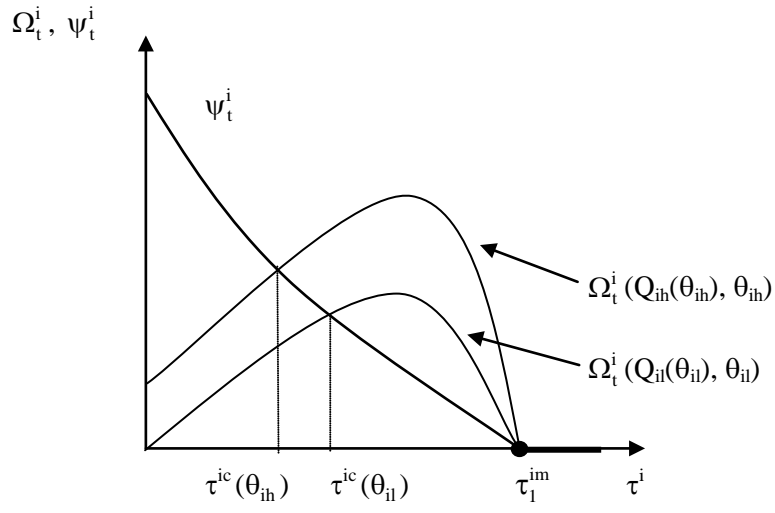
**Figure 2: Inefficient Quality Choice**



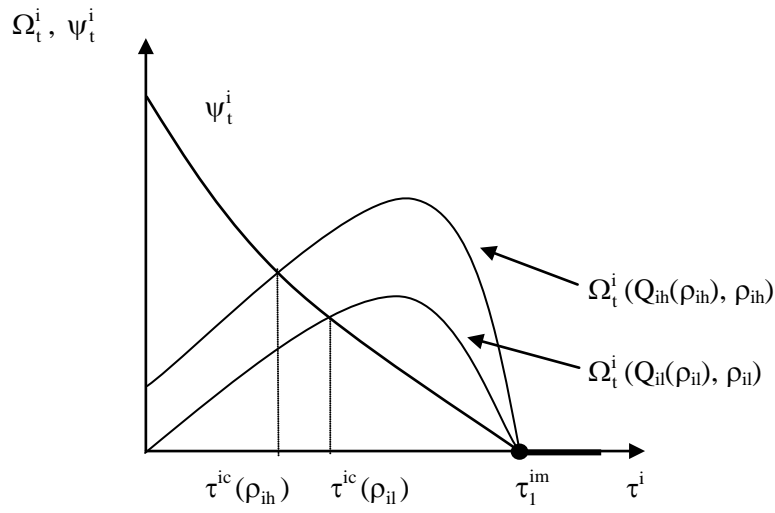
**Figure 3: Determination of  $\tau^{ic}$**



**Figure 4:**  $\theta_{ih} > \theta_{il}$ .



**Figure 5:**  $\rho_{ih} > \rho_{il}$ .



**Figure 6: SDS vs. WDS Quality Choice**

